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Aims and Scope

Educational Technology & Society is a quarterly journal published in January, April, July and October. *Educational Technology & Society* seeks academic articles on the issues affecting the developers of educational systems and educators who implement and manage such systems. The articles should discuss the perspectives of both communities and their relation to each other:

- Educators aim to use technology to enhance individual learning as well as to achieve widespread education and expect the technology to blend with their individual approach to instruction. However, most educators are not fully aware of the benefits that may be obtained by proactively harnessing the available technologies and how they might be able to influence further developments through systematic feedback and suggestions.
- Educational system developers and artificial intelligence (AI) researchers are sometimes unaware of the needs and requirements of typical teachers, with a possible exception of those in the computer science domain. In transferring the notion of a 'user' from the human-computer interaction studies and assigning it to the 'student', the educator's role as the 'implementer/ manager/ user' of the technology has been forgotten.

The aim of the journal is to help them better understand each other's role in the overall process of education and how they may support each other. The articles should be original, unpublished, and not in consideration for publication elsewhere at the time of submission to *Educational Technology & Society* and three months thereafter.

The scope of the journal is broad. Following list of topics is considered to be within the scope of the journal:

Architectures for Educational Technology Systems, Computer-Mediated Communication, Cooperative/ Collaborative Learning and Environments, Cultural Issues in Educational System development, Didactic/ Pedagogical Issues and Teaching/Learning Strategies, Distance Education/Learning, Distance Learning Systems, Distributed Learning Environments, Educational Multimedia, Evaluation, Human-Computer Interface (HCI) Issues, Hypermedia Systems/ Applications, Intelligent Learning/ Tutoring Environments, Interactive Learning Environments, Learning by Doing, Methodologies for Development of Educational Technology Systems, Multimedia Systems/ Applications, Network-Based Learning Environments, Online Education, Simulations for Learning, Web Based Instruction/ Training

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Guidelines for authors

Submissions are invited in the following categories:

- Peer reviewed publications: a) Full length articles (4000 - 7000 words), b) Short articles, Critiques and Case studies (up to 3000 words)
- Book reviews
- Software reviews
- Website reviews

All peer review publications will be refereed in double-blind review process by at least two international reviewers with expertise in the relevant subject area. Book, Software and Website Reviews will not be reviewed, but the editors reserve the right to refuse or edit review.

- Each peer review submission should have at least following items: ▪ title (up to 10 words), ▪ complete communication details of ALL authors , ▪ an informative abstract (75-200 words) presenting the main points of the paper and the author's conclusions, ▪ four - five descriptive keywords, ▪ main body of paper (in 10 point font), ▪ conclusion, ▪ references.
- Submissions should be single spaced.
- Footnotes and endnotes are **not** accepted, all such information should be included in main text.
- The paragraphs should not be indented. There should be one line space between consecutive paragraphs.
- There should be single space between full stop of previous sentence and first word of next sentence in a paragraph.
- The keywords (just after the abstract) should be separated by **comma**, and each keyword phrase should have initial caps (for example, Internet based system, Distance learning).
- Do not use 'underline' to highlight text. Use '*italic*' instead.

Headings

Articles should be subdivided into unnumbered sections, using short, meaningful sub-headings. Please use only two level headings as far as possible. Use 'Heading 1' and 'Heading 2' styles of your word processor's template to indicate them. If that is not possible, use 12 point bold for first level headings and 10 point bold for second level heading. If you must use third level headings, use 10 point italic for this purpose. There should be one blank line after each heading and two blank lines before each heading (except when two headings are consecutive, there should be one blank like between them).

Tables

Tables should be included in the text at appropriate places and centered horizontally. Captions (maximum 6 to 8 words each) must be provided for every table (below the table) and must be referenced in the text.

Figures

Figures should be included in the text at appropriate places and centered horizontally. Captions (maximum 6 to 8 words each) must be provided for every figure (below the figure) and must be referenced in the text. The figures must **NOT** be larger than 500 pixels in width. Please also provide all figures separately (besides embedding them in the text).

References

- All references should be listed in alphabetical order at the end of the article under the heading 'References'.
- All references must be cited in the article using "authors (year)" style e.g. Merrill & Twitchell (1994) or "(authors1, year1; authors2, year2)" style e.g. (Merrill, 1999; Kommers et al., 1997).
- **Do not use numbering style to cite the reference in the text** e.g. "this was done in this way and was found successful [23]."
- It is important to provide complete information in references. Please follow the patterns below:

Journal article

Laszlo, A. & Castro, K. (1995). Technology and values: Interactive learning environments for future generations. *Educational Technology, 35* (2), 7-13.

Newspaper article

Blunkett, D. (1998). Cash for Competence. *Times Educational Supplement*, July 24, 1998, 15.

Or

Clark, E. (1999). There'll never be enough bandwidth. *Personal Computer World*, July 26, 1999, retrieved July 7, 2004, from http://www.vnunet.co.uk/News/88174.

Book (authored or edited)

Brown, S. & McIntyre, D. (1993). *Making sense of Teaching*, Buckingham: Open University.

Chapter in book/proceedings

Malone, T. W. (1984). Toward a theory of intrinsically motivating instruction. In Walker, D. F. & Hess, R. D. (Eds.), *Instructional software: principles and perspectives for design and use*, California: Wadsworth Publishing Company, 68-95.

Internet reference

Fulton, J. C. (1996). *Writing assignment as windows, not walls: enlivening unboundedness through boundaries*, retrieved July 7, 2004, from http://leahi.kcc.hawaii.edu/org/tcc-conf96/fulton.html.

Submission procedure

Authors, submitting articles for a particular special issue, should send their submissions directly to the appropriate Guest Editor. Guest Editors will advise the authors regarding submission procedure for the final version.

All submissions should be in electronic form. The editors will acknowledge the receipt of submission as soon as possible.

The preferred formats for submission are Word document and RTF, but editors will try their best for other formats too. For figures, GIF and JPEG (JPG) are the preferred formats. **Authors must supply separate figures** in one of these formats besides embedding in text.

Please provide following details with each submission: ▪ Author(s) full name(s) including title(s), ▪ Name of corresponding author, ▪ Job title(s), ▪ Organisation(s), ▪ Full contact details of ALL authors including email address, postal address, telephone and fax numbers.

The submissions should be sent via email to (Subject: Submission for Educational Technology & Society journal): **kinshuk@ieee.org**. In the email, please state clearly that the manuscript is original material that has not been published, and is not being considered for publication elsewhere.

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Moderators & Summarizers:
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Discussion Schedule:
Discussion: September 7-14, 2005
Summing-up: September 15-16, 2005

Pre-Discussion Paper

"Go confidently in the direction of your dreams. Live the life you have imagined."
Henry David Thoreau (American essayist, poet and philosopher, 1817-1862)

A Dissertation Learner:

"The dissertation process was grueling; it was mind-blowing, back-breaking, and anxiety driven. The dissertation process takes student dedication and a fair amount of intelligence to complete the dissertation, but most importantly what is needed is a focused, understanding, and dedicated mentor to pull you up the dissertation mountain. My dissertation mentor was the main dissertation student contact during my entire academic career and one who understands the dissertation process and aware that completing the dissertation is like climbing a mountain. My mentor was my dissertation mountain climbing guide, and when I stumbled or had aches and pains my mentor dragged me to get to the top."
Dr. Janon S. Berry, Doctor of Management in Organizational Leadership, University of Phoenix Online

Introduction

Blum and Muirhead (2005) have strived to address vital issues associated with mentoring online doctoral students in their e-book *Conquering the mountain: Framework for successful chair advising of online dissertation students.* The purpose of this book is to give online distance education faculty who are dissertation advisor s an explicit framework for enabling distance education doctoral student to complete a dissertation without ever coming face-to-face. Online doctoral programs are growing rapidly and distance educators and administrators are seeking relevant educational paradigms and instructional strategies for their degree programs. The authors share their experiences working with doctoral students in a virtual environment and the paper will highlight a small portion of the insights on mentoring strategies from the e-book.

The doctoral dissertation is one of the most intense academic experiences that individuals encounter in their lives. One of the tragic interpersonal moments in the academic community is when individuals share that they were not able to complete their dissertation. The initial ABD – All But Dissertation that signifies this academic state is a reminder of the difficult journey to earn the coveted doctoral degree. Curran-Downey (1998) related “being in graduate school and making it all the way through the classes, the exams and the defense of the dissertation is ---take your pick--- marathon, wasteland, jungle, rat race” (para 6). The high attrition rate for students in American doctoral programs is a dark aspect of doctoral education that continues to plague the higher education community. It reflects a degree of failure at the institutional level to assist talented individuals in what is often considered the ultimate academic challenge and represents a tremendous waste of human resources that often undermines career plans.

The entire dissertation process for many doctoral students appears similar to a mountain looming in the distance, inescapable, magnificent, but impossible to scale. Online doctoral students face additional challenges overcoming the barriers of distance education (Blum, 1999). Helms and Raiszadeh (2002) found that working in a distance education virtual medium requires more explicit objective setting than face-to-face teams. Dissertation chairs do not have an online explicit list to follow to help distance education students succeed at writing a dissertation despite argument that “ professors can learn advising skills by following some systematic advising processes" (Davis, 2004, para 2) ; previous attempts at successfully mentoring dissertation students are typically trail-and-error learned from past failures and successes (Davis).

Create a Timeline to Climb Mountain Milestones

Successful online doctoral advisors help learners establish as timeline to make milestones clear and doable for the learners. Many advisors use Excel to work with the student to create a timeline, working backwards with the date the student wants to graduate, dissertation due dates, proposal due dates, milestones of the problem, purpose, research questions, and hypotheses creation. The timeline should include Chapter 1, 2, 3, 4, and 5 revisions, edits, and final dates of completion, and factor in revisions of student drafts, chair edits, committee suggestions, and formal approval time by the University. The timeline clearly shows the dissertation student that the mountain is climbable in small steps, one step at a time in a timeframe that meets deadlines and accounts for student work or family commitments is factored into the milestones, as well as any advisor vacations or times when he or she is unavailable. An example of a timeline Blum created with a student for a dissertation proposal is below. Chairs are called *mentors* at some universities.

Mentor and Mentee Contract and Dissertation Timeline Template			
Instructions:			
1. Revision turn around time is based on experience			
2. Enter in the start date of First Dissertation Class and this generates milestones.			
3 Enter all planned conferences and vacations for mentor and mentee.			
4. Mentor reviews and factors in more time based on experience.			
4. Both parties sign the contract and keep a copy.			
5. Timeline revisions required new signatures.			
6. Enter in Dates of Dissertation Online Classes			
8. Have mentees print this out and put next to computer.			
Milestone	**Due date of first Drafts or step accomplished**	**Mentor and Mentee agreed to five day turnaround has five days; 1 day in classes**	**Comments**
Date starting First dissertation-related individual course.	**9-Jan-05**		
Editor confirmed and notified of the time frame. Send this chart to editor	10-Jan-05	15-Jan-05	
Problem statement to mentor	**9-Jan-05**	10-Jan-05	
Edited, suggestions made, returned	10-Jan-05	15-Jan-05	
Revisions Made	11-Jan-05	13-Jan-05	
Edited, returned	18-Jan-05	19-Jan-05	
Revisions Made	21-Jan-05	22-Jan-05	
Approved, or cycle above; the problem DRIVES the entire study so it must be perfect.	23-Jan-05	24-Jan-05	
Milestone	**Due Date**	**Mentor/Mentee Date**	**Comments**
Purpose Statement draft to mentor	**19-Jan-05**	21-Jan-05	
Edited, suggestions made, returned	22-Jan-05	23-Jan-05	
Revisions Made	24-Jan-05	25-Jan-05	
Edited, returned	30-Jan-05	31-Jan-05	
Revisions Made	1-Feb-05	6-Feb-05	
Approved, or cycle above;	11-Feb-05	12-Feb-05	
Research Questions/hypothesis questions	**25-Jan-05**	26-Jan-05	
Edited, suggestions made, returned	27-Jan-05	28-Jan-05	
Revisions made,	29-Jan-05	30-Jan-05	
Committee selected	30-Jan-05	30-Jan-05	
Problem, purpose, questions to committee for suggestions	30-Jan-05	4-Feb-05	
Chapter 1 Draft to Mentor	**4-Feb-05**	9-Feb-05	

Edited, suggestions made, returned	11-Feb-05	9-Feb-05	
Revisions made,	11-Feb-05	16-Feb-05	
Approved, or cycle above;	18-Feb-05	20-Feb-05	
Send to Editor; return to Mentor	20-Feb-05	25-Feb-05	
Approved by mentor or more changes.	27-Feb-05	1-Mar-05	
Send Chapter 1 to Committee	1-Mar-05	6-Mar-05	
Chapter 2 Draft	4-Feb-05	6-Feb-05	
Chapter 2 Revised	8-Feb-05	30-Mar-05	
First Dissertation Class Ends -- grade issued	30-Mar-05		
Milestone	**Date**	**Date**	**Comments**
Chapter 1 committee suggestions incorporated	30-Mar-05	4-Apr-05	
Revisions made; send to mentor with chart of changes, the request, the change itself, and the page number of Chapter 1	9-Apr-05	14-Apr-05	
Approved by mentor or cycle above.	14-Apr-05	19-Apr-05	
Chapter 2 Revised	19-Apr-05	24-Apr-05	
Chapter 2 approved by Mentor	29-Apr-05	4-May-05	
Chapter 3 to Mentor	3-Jun-05	8-Jun-05	
Same cycle, editor to receive all three chapters before sending to committee after mentor approves content; mentor receives one more time after editor before sending out.	18-Jun-05	23-Jun-05	
Committee receives mentor approved, edited Proposal with chart of changes; all three chapters.	3-Jul-05	8-Jul-05	
Changes requested, revised with chart.	18-Jul-05	23-Jul-05	
Year 3 Residency Complete	28-Jul-05	4-Aug-05	
Milestone	**Date**	**Date**	**Comments**
Mentee on Vacation	**4-Aug-05**	**9-Aug-05**	
Committee receives final copy for signatures.	3-Sep-05	8-Sep-05	
Requested changes if any, made and back to committee to sign	23-Sep-05	28-Sep-05	
Mentor on Vacation	**28-Sep-05**	**3-Oct-05**	
ARB/IRB receives proposal	13-Oct-05	27-Oct-05	
Changes requested, only these changes are made, resend; or approved.	11-Nov-05	26-Nov-05	
ARB and IRB approve proposal	10-Dec-05		
One on One Dissertation Class -- Chapter 4	24-Jan-06	25-Mar-06	
One on One Dissertation Class -- Chapter 5	26-Mar-06	25-May-06	
Edits of Entire Dissertation	24-Apr-06		
Dissertation to Grammar and APA Editor	26-Apr-06		
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Committee last edits done	30-Apr-06		
Committee Signatures obtained on hard-copy	30-Apr-06		
Deadline to Upload to Dean	**16-May-06**		
Milestone	**Date**	**Date**	**Comments**
Dean's requested changes made and re-sent	30-May-06		
Committee hard-copy new signature obtained -- if needed	30-May-06		
Deadline for Dean's Signature	**6/1/2005**		
Graduation	7/30/2006		
By signing the below, I agree to the timeline and this contract.			
and my schedule must be revised with new signatures and dates.			
Mentee Signature		Mentor Signature	Date
Sign Here		*Sign Here*	Date Signed

Name of mentee		Name of Mentor	
Mentee Contact Information		Mentor Contact Information	
Address:		Address:	
City, State, Zip		City, State, Zip	
Home Phone		Home Phone	
Cell:		Cell:	

Finally, chairs who are most successful at reducing online dissertation student fear simply pick up the phone and walk the student through the initial processes, mapping out what needs to be done and when. Advisor follow-through with encouraging emails keeps provide positive feedback that builds confidence and lowers unnecessary anxiety. One of the author's of this article chair at Walden University used to send out postcards simply saying hello to the dissertation student, and this practice always reduced levels of anxiety, especially the postcard stating the mentor was alive and well after a Costa Rica rafting trip (the mentor was older than 60 at the time).

The Literature Review Process

Tremendous expansion of electronic information resources has exponentially increased research opportunities. This fact makes it important that students are properly prepared to use the new technologies. Hart (1998, p. 5) has identified two basic types of skills required for researchers:

1. **Core skills and abilities** - while the differences make subject disciplines distinctive, there exists a common core of skills and attitudes which all researchers should possess and should be able to apply in different situations with different topics and problems.
2. **Ability to integrate theory and method** - research for all disciplines involves an understanding of the interrelationship between theory, method and research design, practical skills and particular methods, the knowledge base of the subject and methodological foundations (Hart, 1998, p. 5).

Reviews vary greatly in the scope and depth of material examined. The selection of study topic is a key factor and students should avoid selecting topics that transcend the requirements of their degree programs. A primary reason for studying the literature is to demonstrate familiarity with research in the field and establish credibility for the individual's current investigation. The literature review should reflectively build upon the work conducted by other researchers who are part of a larger intellectual community (Neuman, 1997).

The dissertation committee expects students to produce literature reviews that uphold high academic standards. Neuman (1997, p. 89) described four major literature review objectives:

1. **To demonstrate a familiarity with a body of knowledge and establish credibility**
   A review tells a reader that the researcher knows the research in an area and knows the major issues. A good review increases the reader's confidence in the researcher's professional competence, ability, and background.
2. **To show the path of prior research and how a current project is linked to it**
   A review outlines the direction of research on a question and shows the development of knowledge. A good review places a research project in a context and demonstrates its relevance by making connections to a body of knowledge.
3. **To integrate and summarize what is known in an area**
   A review pulls together and synthesizes different results. A good review points out areas where prior studies agree, where they disagree, and where major questions remain. It collects what is known up to a point in time and indicates the direction for future research.
4. **To learn from others and stimulate new ideas**
   A review tells what others have found so that a researcher can benefit from the efforts of others. A good review identifies blind alleys and suggests hypotheses for replication. It divulges procedures, techniques, and research designs worth copying so that a researcher can better focus hypotheses and gain new insights.

The literature review helps the student to understand the historical context of their subject while focusing on current research efforts (Hart, 1998). Literature reviews offers opportunities for students for learning how to identify areas of concern and it increases their awareness of any neglected issues.

Give Dissertation Students Direct Advice That Works

Marilyn Simon has assisted hundreds of online doctoral students in a successful completion of the doctoral dissertation. Simon shares some helpful hints that chairs should share with dissertation learners to climb the dissertation mountain: (Muirhead, Robinson & Simon 2005, pp. 15-16)

- **Develop a thick skin.** Dissertation students are striving for perfection; a lofty and extraordinary aspiration. Dissertations require a great deal of work. This is likely the first time a dissertation student is conducting a doctoral dissertation so you need to understand the process, and understand the advice of the dissertation chair; it likely that dissertation students will do more re-writes than the student can count. Dissertation student must develop the attitude that each critique is good advice, and each feedback received will move the student closer to the top of the dissertation mountain.
- **Keep in constant contact with the mentor or chair** . Dissertation students should develop a working rhythm with the chair and send component parts of major sections of the dissertation proposal work as it becomes available.
- **Manage time wisely.** The key point in time management is recognizing the finite nature of time as a resource; this is both good news and bad news. The bad news, of course, is that time is limited. Time moves at the same rate and there is no way to manipulate the passage of time. The good news is that time is a constant. Time is known and, hence, its stability provides a basis for predicting future outcomes. Good time management includes program planning whereby resources (people, time) are effectively managed. Effective time management includes making time for loved ones and time to de-stress. Daily work is made easier when a model provides a continuing guide for action, various levels of accountability and responsibility, and when essential tasks and sequences of tasks are specified along with a timeline for completion
- **Develop a dissertation student support system** . Commiserate with someone who is going through the same process, trying to climb an equally high dissertation mountain. Make sure to include family and close friends in planning and share dissertation difficulties with them. If the dissertation student does not have current friends who would understand, find new friends that have been there or are at the same part of the dissertation mountain.
- **Consult experts as needed in the dissertation process**. For example if plans include hiring a dissertation editor ensure the editor has experience working with doctoral-level scholarship. Ask other students who have recently completed a dissertation or the chair for referrals. If you plans include a statistician make certain that the statistician can explain every step of the process to because the dissertation student is are responsible for every component of the dissertation and must explain and defend all tests and measurements used in the dissertation.

Teach Students to Slow Down

The mountain of fear of the dissertation process is a huge barrier for doctoral students. The mountain of the dissertation can cause an otherwise highly intelligent student who has earned full credit for all doctoral classes to run. Sometimes the student runs the other direction and quits the doctoral program becoming *an all but dissertation* for the rest of the student's life. Another student reaction to the dissertation mountain is to attempt to complete the entire dissertation at a full-fledged run up the mountain. Similar to attempting to run up an entire mountain, attempting to write an entire dissertation in a short time frame results in failure.

Writing the proposal is the first step to succeeding at scaling the dissertation mountain, previous chapters in this book addressed how to write chapters 1, 2, and 3. The success subsequent chapter depends on the clarity and content of previous chapters, and the learner should work on each section at a time. For example, chapter 3 includes some of the exact statements found in chapter 1; so the development of chapter 1 is the first step. Chapter 4 will have many of the literature findings as supporting citations found in chapter 2. Writing successful proposals takes time and reflection. Students try to write the entire proposal quickly and tend to get frustrated when the proposal is not approved in a short time frame and no clear 1-10 plan of what to do next. The plan depends on the problem, access to data, and the design, and good chairs work hard to slow the students down to reflect on the steps needed for success.

Editing and Reflecting – Resting at Switchbacks

Similar to the manner a hiker rests while climbing, a dissertation learner should rest for short time periods when writing and editing the dissertation in order to reflect and make changes to increase clarity for the reader. The key is to rest for short time periods, because if the learner rests for a long time period, similar to cramps the hiker may experience when starting back up the mountain after too long of a rest, the dissertation student has trouble starting the dissertation climb again. Resting for short time periods and starting again refreshed often results in the student finding errors in content, grammar, formatting, and APA; errors in any error causes a rejected proposal. Non-stop writing causes student burnout, ABD's, and an inability to see writing errors.

Using Committee Feedback – Talk to Climbers Coming Down the Mountain

By the time the chair has edited the proposal and has deemed that, the proposal meets the university's checklist of proposal requirements; the average chair has the entire document memorized and finds it difficult to see any additional errors to edit. When the proposal is the stage where the mentor cannot find any more errors, the committee suggestions are invaluable. Similar to the climber who is trying to make his or her way up the mountain, gathering information from climbers who have already been to the top helps the learner keep going, gives time for reflection, and valuable inputs to make the dissertation better with more chances for success.

Chairs should help learners find good committee members that possess the skills needed to succeed the dissertation mountain climb. For example, if the chair has strong qualitative skills but does not have a great deal of leadership background, and the learner is working on a qualitative leadership subject dissertation, asking a committee member to join the committee with strong leadership knowledge would round out the skills needed for learner success. Another committee member with both leadership and qualitative experience would add considerable value to the team. Learners often select committee members based on nothing but exposure to meeting the faculty member in a class; directing students about how to select committee members results in the creation of a better team with skills needed by the learner to succeed. Teaching the learner about the reasons why committee selection is critical can overcome the selection of a team that does not have the skills needed by the learner.

A good committee member will check the content, design, APA, and transitions in the proposal. A committee member who returns the proposal with nothing more than a "good job" or "excellent work" has not helped the learner improve the dissertation nor has the committee member worked as a team to help the learner succeed. Some chairs recommend the student find new committee members at this early stage to avoid problems with failure to provide good suggestions with the final dissertation.

A good practice is to have a meeting on the phone or using emails and tell the committee what to expect from the learner; the chair should inform the committee what to expect from the learner and at what points in time. For example, the chair in this article sends an email to the selected committee members, informing the committee feedback is needed when the chair approves the problem, purpose, and research questions/hypotheses as ready for committee suggestions, chapter 1 is ready for comments and editing, chapter 1, 2, & 3 and a change chart incorporating all committee suggestions into chapter 1 and 3, and one more time for a final signature with additional committee suggestions on the entire dissertation proposal with a change chart reminding the committee of each suggestion. The final dissertation is sent to the committee for one more round of suggestions, and re-sent after revisions for final committee signatures and to schedule the learner's Dissertation Orals.

Publishing

Students who have conquered the mountain and completed their dissertation are initially exhausted. It is a natural response to a rigorous academic journey. The process of writing for academic publication is a unique professional challenge that requires being dedicated to creating professional writing goals. Individuals who have completed their dissertation would like to publish but are not quite sure how to get started. Chairs can offer advice on how to develop a practical writing plan that will increase student opportunities for academic publication.

Students who have just completed their dissertation have a tendency to neglect writing articles from their research project. Sadly, the dissertation and related notes are stored in files and boxes but not used for publication purposes. Chamberlin (1999) relates "… many others--relieved that the tome is finally behind them--let theirs collect dust on their desks or pack their notes and files into storage. One reason, say faculty, is that many recent graduates dread transforming their dissertations into journal articles" (para 3). It is wise to seek advice from people who have publishing experience such dissertation faculty members. Converting dissertation research into a journal article requires being selective about the material being used, having a writing plan to revise the information into a relevant format and highlight the most important findings. The article must be clear and readable which means avoiding a quick cut and past job which could undermine the potential for publication (Chamberlin, 1999).

Conclusion

The mountain metaphor highlights the enormous task of writing a successful doctoral dissertation. Students gain valuable experience climbing the dissertation mountain and overcoming a diversity of obstacles that can derail the most dedicated individuals. Chairs play a vital role in guiding and assisting online students to effectively complete their dissertation projects to become skilled researchers.

Online universities must provide the best support system for their doctoral dissertation students. The University of Phoenix and Walden University require faculty members to successful complete training before becoming mentors. The primary goal of the training is to help prepare individuals to be effective instructors who will have the skills, knowledge and confidence to independently guide their students. Mentor training programs or workshops should:

- be an intentional, structured process
- be a nurturing process
- be an insightful and reflective process
- be a supportive process (SchoolNet, SA, 2000, para 1).

Discussion Questions

1. Why has there been a persistently high attrition rates in today's doctoral programs?
2. What type of quality controls should be in place in online doctoral programs that will help students to produce scholarly and relevant dissertations?
3. What advice would you give doctoral students in selecting a mentor?

[This list of questions should not be considered an exclusive list of topics for this discussion.]

Post-Discussion Summary

The discussion did raise some questions about the nature of differences between the traditional and online doctorate programs. A central question focus on whether there existed any substantial differences in the quality of mentoring advice and student preparation. Muhammad Betz stated "I debate with myself the value of the one in comparison to the other. I wonder if I have biases towards online doctorates (which all include residency requirements). It is my conclusion that online and traditional programs are indeed different, but that the differences don't necessarily indicate an authentic qualitative difference."

Student article publications and presenting research papers at conferences can be considered one indicator of a quality program. Online and traditional doctoral students both publish and present their work at conferences. The University of Phoenix and other online institutions have students who are involved in these academic endeavors. Therefore, the publication argument does not provide any significant difference between the two educational models. There were concerns about online doctoral faculty working other jobs might have a negative impact on their mentoring duties. Again, traditional university teachers have outside jobs, business ventures and consulting work which could be similarly viewed in a negative perspective. Students want mentors who have real world experience and expertise which helps them create scholarly dissertations that make a positive difference in a diversity of academic fields.

Today's online institutions are distinctive for having training programs which provide materials and guidance to equip mentors with specialized knowledge and insights into effective mentoring practices. It should be noted that none of the discussion participants mentioned any training programs for mentors at traditional universities. Perhaps, this reflects a tendency to affirm academic independence but it could be detrimental to the students who fail to receive adequate and timely guidance from their mentors. There is a degree of complacency among higher education leaders over the loss of many of their doctoral students who never graduate. Leaders can rationalize flaws in the dissertation process by believing that only the best learners have survived. Sadly, the absence of accountability has left too many people with nothing to show for their years of hard work except large university loans, negative memories and broken dreams.

Donna Russell raised the question "How do you initiate and sustain these interpersonal relationships in your online programs?" This is a vital question involving personalization of online academic relationships. The authors have mentored dissertation students online and they use a variety of ways to encourage positive interactions with their students. For instance, email notes can be used to share research resources and check to see how students are progressing. The notes are designed to provide both practical advice and encouragement as students seek to conquer the dissertation mountain. Friodon Wild observed that "the important aspects of the doctorate (high quality research) can be done virtually anywhere, and it's only the workplace situation that partially makes a difference."

Further research is needed into administrative and instructional strategies to provide the best guidance to doctoral students and investigate ways to help lower attrition rates. Student exit interviews would be a valuable tool to identify specific reasons for students departing from their degree programs. Michael Lawrence-Slater highlighted the importance of obtaining accurate data to develop informed perspectives on student dissertation work. The authors acknowledge that both online and traditional universities struggle in how to effectively offer the best preparation for students. Mentoring dissertation projects requires patience and wisdom when working with individuals who vary in their knowledge and research skills.

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Future developments of IMS Learning Design tooling

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Introduction

In February 2005, a meeting of the UNFOLD project (see http://www.unfold-project.net) took place in the Netherlands,. The meeting gathered together around 50 people from all over the world who are using the IMS Learning Design specification in their own educational practice, or in designing software tools that utilize the specification. The group of instructional designers, teachers, learning providers and tool developers worked together in creating and exploring Units of Learning with recently developed tools (editors & players) which implement the IMS Learning Design specification. The focus of this discussion paper elaborates on that of the meeting: in which direction should the IMS Learning Design tooling develop in the near future?

The IMS Learning Design (IMS LD) specification has been available for 2½ years. It is a new and interesting development, and tools and materials are becoming available. UNFOLD has produced a number of resources for those interested in the specification, including a list of Frequently Asked Questions, explanatory material, short courses and example Units of Learning (UoLs). Articles describing research and development involving IMS LD are now becoming available (Griffiths, Blat, Elferink & Zondergeld, 2005; Karampiperis & Sampson, 2005; Koper & Olivier, 2004; Koper & Tattersall, 2005; Tattersall & Koper, 2005).

Few instructional designers and teachers have, however, experience in designing learning materials using IMS LD, which requires the use of an editing environment and runtime 'player', accessed by learners. The availability of the first tools can be considered as the start of a new phase in the life of IMS Learning Design, progressing from the written specification, to the use of the Learning Design concept represented by tools such as editors and players.

Who is the user of IMS Learning Design?

People applying Learning Design in actual educational settings are not necessarily interested in the details of the IMS LD specification, or how it is implemented by applications such as editors, content management systems, players and VLEs. Realistically speaking, a sound knowledge of the specification is needed to use today's tools to create UoLs. The prevailing question is: which road should be taken: to aim at specialist or generic users?

One position is to keep the tooling suited for those trained in instructional design in general, and specifically the application of Learning Design, since the specification is too complex to have tools simplify the authoring process. As a result, a sound knowledge of the specification is needed to be able to apply it. In this scenario, it is not expected that teachers build their own Learning Designs but merely arrange available Learning Designs to make them suit the educational context. A second prevailing scenario is for teachers not only to arrange existing Learning Designs (re-use) but also build their own Learning Designs from scratch. Current tooling does not yet meet the demands of this scenario. How much effort should we put in the usability of the authoring tools?

Tool usability

IMS Learning Design may be complex to use in practice, but it is flexible in the kind of Learning Designs that can be created. Current authoring tools offer generic editing possibilities. Are these sufficient for specialized designers? Are they suitable for teachers? Will more sophisticated tools in which templates, wizards or patterns can be used help? Or is IMS LD too complex to expect easy to use authoring tools?

The future of LD tools

Learning Design is sometimes seen as being particularly suited for educational contexts such as distance education, in which learning activities are typically planned in advance and students learn in a reproductive manner. In the specification, the design of learning activities is separated from everything that happens in runtime between the roles specified in the UoL. In such situations learners may not follow a planned UoL completely, they may define on the spot their own, unspecified learning paths, and produce their own materials as part of their learning activities (self-directive learning). The situations mentioned can be expressed in IMS LD as a transcript of learning activities that took place. How are we going to deal with these issues? Should the distinction between authoring environments for creation of UoLs and the virtual learning environment for running them disappear? Should the actual activities and products of learners generate UoLs to be stored and reused?

Discussion

Five attendees of the UNFOLD meeting shared their views on the discussion points raised.

1. IMS LD tooling requires specialist expertise in putting together Learning Designs. Who are the designers?

All those involved in the discussion identified both instructional designers and regular teachers as designers of education and users of the IMS LD specification. The difference between these groups lies in the level of complexity of the Learning Designs that may be expected to be built. Instructional designers may create specific pedagogical designs that can be used by teachers who connect the designs with actual learning contents. Teachers should be able to construct Level A UoLs as long as they are not confronted by the ins and outs of the specification itself and the tooling is very user-friendly. Level B and C designs are feasible for advanced users who can put more time and effort in studying the details of IMS LD.

Everyone stressed the need for user-friendly tools, where the concept of designing education and the user interface are transparent and easy to understand. Without this level of support, the hurdle is too high for teachers. Commercial developers of authoring tools have learned this lesson, but tools still often lack support for the latest specifications and standards. Universities, as customers of both authoring tools and VLEs, need to urge vendors to adopt specifications like IMS LD.

In addition, it was noted that in many R&D institutes around the world, software is being developed that uses IMS LD. As a result, there are lots of resources for the development of technology. A bottleneck in many Universities is that staff do not have enough time to develop e-learning materials, since this kind of task is undervalued. Organizational change is needed to realise the potential of new specifications and tools in University education.

The involvement of regular teachers and professional instructional designers is needed to further educational innovation through the development and sharing of Learning Designs. Ultimately, individual teachers are the carriers of educational innovation in their institutes. Opportunities for this are created by instructional designers who in explorative projects guide new directions of educational innovation.

2. How should we improve authoring tools? Tuning them to the needs of different kind of users? Making them more sophisticated? How?

Regarding this question, those interviewed warned against reinventing the wheel. There are many authoring tools available with too many features. Tools need to be customizable to offer basic functions that are to be used by authors, presented in an easy to use, transparent user interface and integrated in (test-) players and content management systems. One suggestion is to involve regular educators in usability tests of the various tools that are being developed by the Research community. Another route is to use widely available authoring tools implementing IMS LD level A (as a minimum), which are accessible for regular teachers. The Learning Designs themselves can be shared and improved.

The exact meaning of user-friendly tooling is open to discussion. A graphical user interface, where one can move around the IMS LD elements, explanation of required information, and support for the steps in the design of UoLs were all mentioned by the interviewees, without a strict prioritisation. The tools available during the

UNFOLD workshop were used with some difficulty by the interviewees, who consider themselves fairly skilled users of computer software. For many others, the hurdles to use the tools are considered high. One suggestion is to actually integrate Learning Design in a complete VLE suite, in which the authoring and delivering of courses is integrated, completed with a full import and export of IMS LD designs. This approach would support self-directed learners, who design their own personal educational arrangements with little involvement of teachers, and might encourage more involvement of peer-students planning group activities together.

3. Learning Design is sometimes considered particularly suitable for educational contexts such as distance education, in which learning activities are often planned in advance and students learn in a reproductive manner. Which direction(s) do you see for future developments of Learning Design?

Everyone is aware of the potential of IMS LD, in which various pedagogical designs can be specified. At the same time IMS LD is inherently complex. As can be seen from the statements made so far, the balance needs to be found between encouraging educators to use the basics on a broad scale and utilizing the advanced possibilities in specific educational settings. Distance education is one such setting, but the interviewees mentioned other situations such as blended learning and self-directed learning. The specification is not perceived as something only suited for distance education. For example, in many businesses there is a need for flexible custom-made and just-in-time learning; IMS LD could be very valuable in combination with tools that can be tuned to one's needs. The possibility of incremental adaptation and reuse of UoLs is considered very valuable, as educators do not have a common language in which educational designs can be expressed.

IMS LD is considered generic. Different tooling can by its design and specific features specially suit different educational contexts; there is no size that fits us all.

Conclusions

Given the discussion triggered by the three main questions one can conclude that IMS LD is considered a complex but powerful concept. The perceived use, range of tooling and suitable educational context is seen as broad.

Interestingly, some of the suggestions have echoes international projects that choose to use the IMS-LD specification. Peer-reviewing and reuse of pedagogical patterns expressed in UoLs is being examined by the Learning Design Research Group of the University of Waterloo (see http://lt3.uwaterloo.ca/innovation/ldrg.html). The use of an authoring environment suited to certain instructional designs is being investigated by the group developing the Collage editor, focussing on the building of collaborative designs (see: http://gsic.tel.uva.es/collage). The Sled (Service-based Learning Design System) project is developing a new IMS LD player, using a web interface to remove software installation issues (see http://sled.open.ac.uk/). Furthermore, evaluative projects are being undertaken within institutional contexts to reveal how IMS LS can be used to support learning and teaching in a real context (see http://www.hope.ac.uk/slide/)

Now that the first tools and resources are available and have been used by different user groups, the dialogue around IMS LD is moving from 'what is it' to 'who is it for and how can it be put to good use'. The answer to this question may well come in several flavours; although IMS LD is an interoperability specification, its use has repercussions beyond file formats. IMS LD gives learning activities a central place, orchestrating learning objects and learning services in the attainment of learning objectives. Few of today's Virtual Learning Environments reflect this philosophy, and few educators are able to see their desired pedagogical approaches reflected in e-learning environments. Change is in the air, and new initiatives around IMS LD are aiming to progress its original aims of improving the quality of e-learning, not only for educators, but also for learners.

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Current Research in Learning Design

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ABSTRACT

A 'learning design' is defined as the description of the teaching-learning process that takes place in a unit of learning (eg, a course, a lesson or any other designed learning event). The key principle in learning design is that it represents the learning activities and the support activities that are performed by different persons (learners, teachers) in the context of a unit of learning. The IMS Learning Design specification aims to represent the learning design of units of learning in a semantic, formal and machine interpretable way. Since its release in 2003 various parties have been active to develop tools, to experiment with Learning Design in practice, or to do research on the further advancement of the specification. The aim of this special issue is to provide an overview of current work in the area. This papers introduces Learning Design, analyses the different papers and provides an overview of current research in Learning Design. The major research issues are at the moment: a) the use of ontologies and semantic web principles & tools related to Learning Design; b) the use of learning design patterns; c) the development of learrning design authoring and content management systems, and d) the development of learning design players, including the issues how to use the integrated set of learning design tools in a variety of settings.

Keywords

Learning Design, Instructional Design, IMS Learning Design, Educational Modelling Language

Introduction

Since the publication of the IMS Learning Design specification in February 2003 (LD, 2003) various parties have been active to develop tools, to experiment with Learning Design in practice, or to do research on the further advancement of the specification. The aim of this special issue is to provide an overview of current work in the area.

Authors were invited to submit papers that were, after acceptance by the reviewers, presented and discussed in a workshop. The workshop was organised by the European Commissions' project UNFOLD (IST-FP6-1), in collaboration with the PROLEARN network of excellence (IST-FP6-2), and took place at 22-23 September 2005 in Valkenburg aan de Geul, the Netherlands. About 60 participants were present and 22 papers were present, among which 10 papers of this special issue. Besides the authors for this special issue, we also invited the authors of a special issue of the Journal of Interactive Media in Education (JIME: Advances in Learning Design, 2005) that had been completed recently. In this introductory paper I will introduce the articles of this special issue against the background of the discussion topics we identified in the workshop.

The structure of this paper is as follows. First I will provide a short summary of IMS Learning Design (aim, design requirements and the roadmap for implementation). This is followed by a themed discussion of the different papers in this special issue. In the conclusion I will summarize the issues for future research.

The Learning Design Specification

The IMS Learning Design specification aims to represent the 'learning design' of 'units of learning' in a semantic, formal and machine interpretable way (Koper & Olivier, 2004). A 'unit of learning' can be any instructional or learning event of any granularity, e.g. a course, a workshop, a lesson or an informal learning event. A 'learning design' is defined as the description of the teaching-learning process that takes place in the unit of learning. The key principle in learning design is that it represents the learning activities and the support activities that are performed by different persons (learners, teachers) in the context of a unit of learning. These *activities* can refer to different *learning objects* that are used during the performance of the activities (e.g. books, articles, software programmes, pictures), and it can refer to *services* (e.g. forums, chats, wiki's) that are used to collaborate and to communicate in the teaching-learning process.

The IMS Learning Design specification is developed to meet some specific requirements:

1. *Completeness*: The specification must be able to fully describe the teaching-learning process in a unit of learning, including references to the digital and non-digital learning objects and services needed during the process. This includes:
   a) Integration of the activities of both learners and staff members.
   b) Integration of resources (learning objects and communication/collaboration services) used during learning.
   c) Support for both single and multiple user models of learning.
   d) Support for mixed mode (blended learning) as well as pure online learning.
2. *Pedagogical expressiveness*: The specification must be able to express the pedagogical meaning and functionality of the different data elements within the context of a Learning Design. While it must be sufficiently flexible to describe Learning Designs based on all kinds of pedagogies, it must avoid biasing designs towards any specific pedagogical approach.
3. *Personalization*: The specification must be able to describe personalization aspects within a Learning Design, so that the content and activities within a unit of learning can be adapted based on the preferences, portfolio, pre-knowledge, educational needs and situational circumstances of users. In addition, it must allow the designer, when desired, to pass the control over the adaptation process to the learner, a staff member and/or the computer.
4. *Compatibility*: The specification must enable learning designs to use and effectively integrate other available standards and specifications where possible, such as the IMS (imsglobal.org) and IEEE LTSC (ltsc.ieee.org) specifications.

Because a Learning Design specification extends existing specifications, it also inherits most of the more general requirements for interoperability specifications and standards, more specifically:

1. *Reusability*: The specification must make it possible to identify, isolate, de-conceptualize and exchange useful learning objects, and to re-use these in other contexts.
2. *Formalization*: The specification must provide a formal language for learning designs that can be processed automatically.
3. *Reproducibility*: The specification must enable a learning design to be abstracted in such a way that repeated execution, in different settings and with different persons, is possible.

The IMS Learning Design specification consists of several components. First of all it consists of a conceptual model (an ontology) for the description of teaching-learning processes. This model is expressed as an UML model (see figure 1).

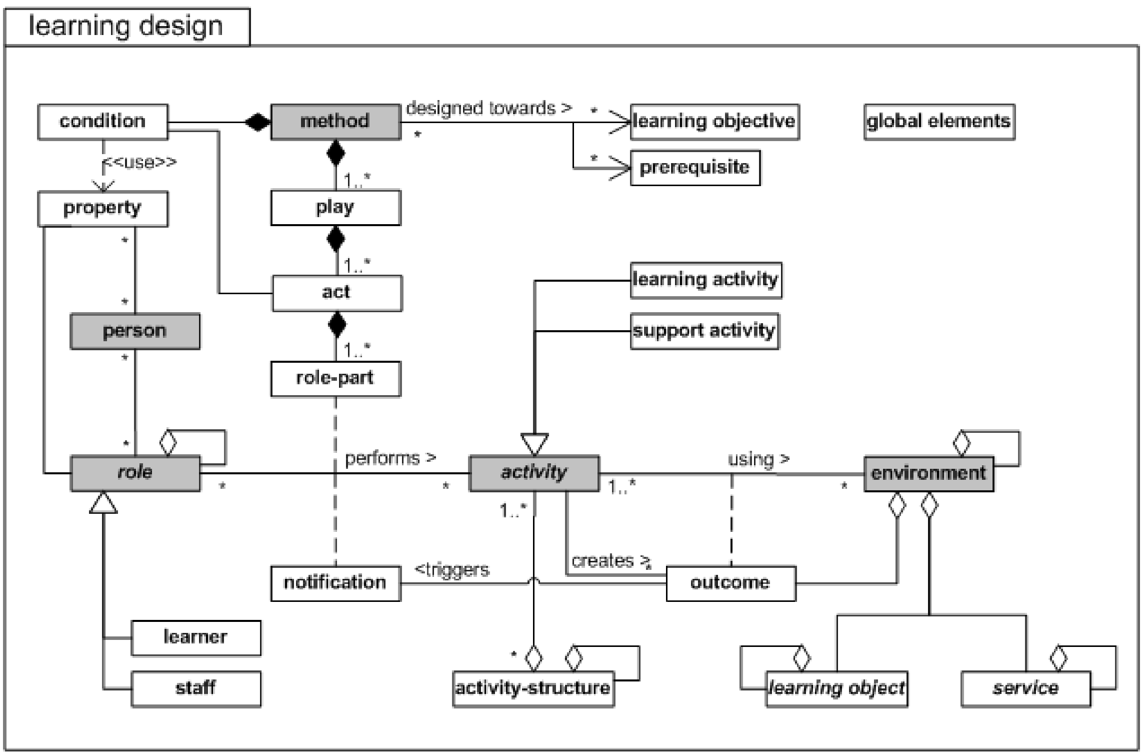

Figure 1. The conceptual model of IMS Learning Design

In essence the model says that learners perform a set of learning activities using learning objects and services (to be found in the activity *environment)* in order to attain some explicit or implicit learning objectives. As a result of the activities, the learners produce outcomes (e.g. reports, forum/wiki contributions, etc.) that subsequently can be used by others in their learning or support activities (e.g. a teacher can provide feedback to a report written by a learner).

Teachers, other staff members or peers can perform support activities to help learners when needed. The design can be static or adaptive, taken into account the existing competencies, needs and circumstances of the persons involved.

The second component of the specification is the Information Model. This document specifies exactly how the entities in the conceptual model relate to each other. Furthermore it contains a description of the expected behaviour of runtime systems. The information model is the core document of the specification.

The third component of the specification is the Best Practices and Information Guide. This guide specifies some use cases and (expected) best practices.

The fourth component is called a 'binding', that is the technology used to represent the information model. The learning design specification is delivered with several bindings: a series of UML diagrams (Vogten, Verhooren, 2002), an XML schema (see figure 2) and XML DTD's. The UML diagrams were created from the initial DTD. The tables in the information model and the XML schema's were automatically generated from the UML diagrams.

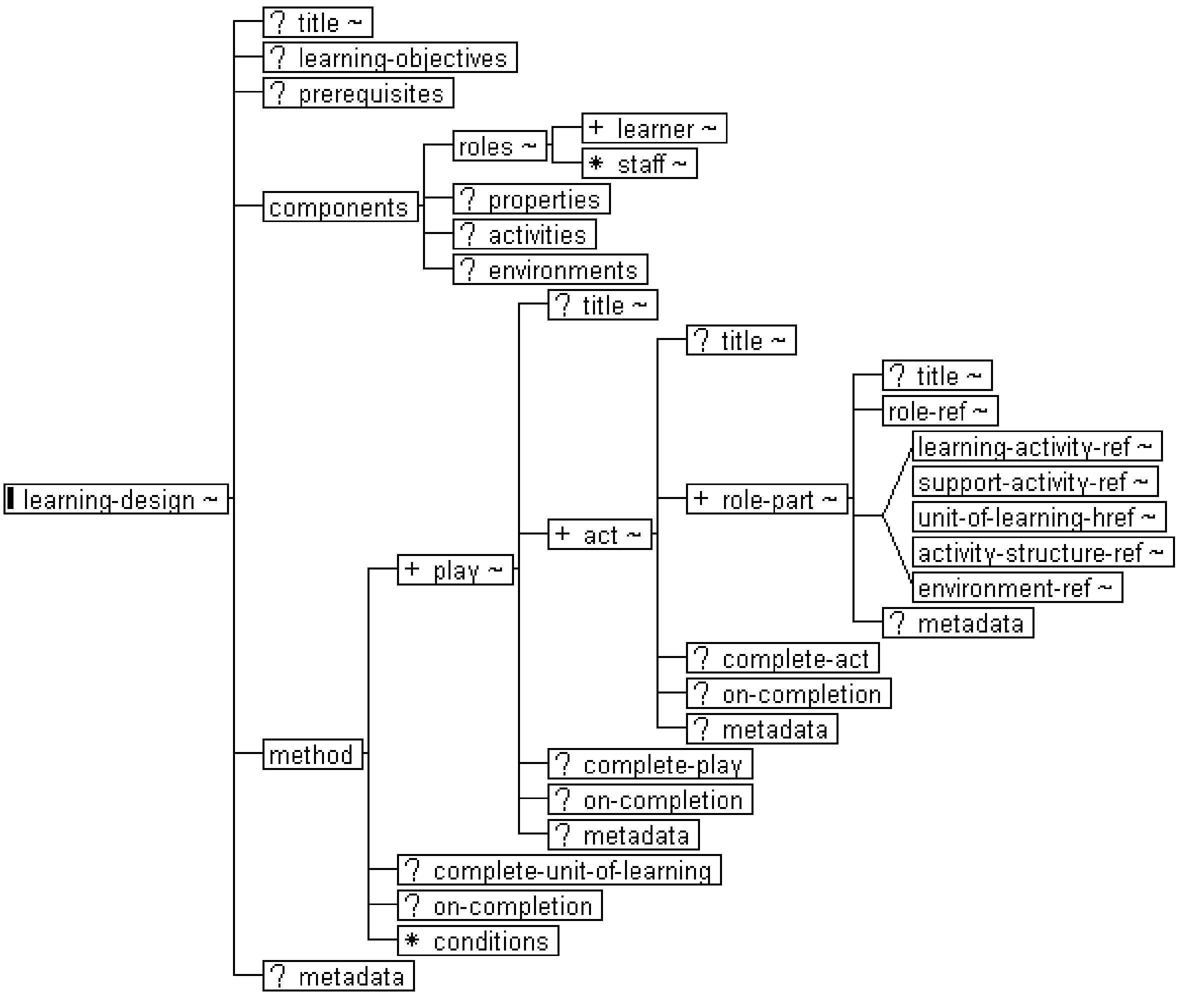

Figure 2. Part of the XML schema tree of IMS Learning Design

The result of this all is that a teaching-learning process can be codified into an XML file with references to the learning objects and services needed to perform the activities. In practice, IMS Learning Design is used to create a zip-file using the IMS Content Packaging specification (CP, 2004). This zip-file can be exchanged and interpreted by any learning design aware runtime engine. This engine will manage the workflow ('activity management') by presenting all the actors with adequate activities and resources at the right time in the teaching-learning process.

For instance, when the design of a unit of learning is as follows:
1. Learners discuss a problem with each other, analyse it and search for background information.
2. Learners discuss possible solutions and decide upon a preferred course of action. This is written into a report.
3. The teacher reads the report and provides formative feedback: additional resources to look at, identifies problems with the proposed solutions.
4. The learners correct the report and send it in for grading.
5. The teacher grades the report.

In this design there is a sequential ordering of five activities. Each person within a learner group will get the first activity; this can be something like this:

> *Activity Description:*
> Attached you will find a problem that you have to solve in collaboration with your fellow students. Discuss the problem with your fellow students (e.g. using the forum or in a class room). Search and study material that you think is necessary for the solution of the problem (using the library and/or Internet resources).
>
> *Environment (learning objects and services):*
> Problem
> Forum
> Internet Resources

The result of the second activity is that the learner group will produce a report (outcome). The teacher will be notified that the outcome of group X is available and s/he will get the support activity to provide feedback to the report. When the teacher has provided the feedback, the learners will be notified and get learning activity 4. When activity 4 is completed, the teacher is notified that the report is send in for grading. The learners again will get a notification of the teachers grade.

It is good to notice that IMS Learning Design is nothing more or less than the set of aforementioned components: some documents and some bindings. Before the specification can be used in practice, several tools have to be developed: authoring tools, content management systems and runtime environments. The roadmap for the practical implementation of Learning Design was defined as follows (Koper, 2004):
1. Specification (February 2003)
2. Awareness Raising (February 2004)
3. First generation of tools (February 2005)
4. Demonstrators, usability improvement of tools, application profiles and conformance testing (2005/2006)

Actual use of Learning Design in practice and the development of a community of users (> 2006).

At the time of writing it is October 2005. Where are we now in this roadmap?

In the period 2004-2005, the European Commission funded the project UNFOLD (2004) to support the co-ordination and dissemination of Learning Design activities. The project was highly successful: many meetings were organised throughout Europe. The participants came from all over the world. People presented their work to each other, were trained to use the newly developed tools, tested the interoperability of tools, discussed the design of new software and informed each other about new plans. In conjunction to this, the EU funded the TELCERT project (2004) that is working on application profiles and conformance tests for a variety of specifications, among which Learning Design. The results should be delivered in 2006. Also the EU project PROLEARN (2004) has the coming years some work packages that are directed to IMS Learning Design. Outside Europe, the Canadian LORNET project (2004) is, among other things, working on learning design ontologies and authoring environments. Besides these large scale funded R&D projects, many smaller projects, e.g. PhD research work, is executed at the moment all over the world. Some of the work is reported in this special issue.

The first tools indeed appeared in the beginning of 2005. At the moment there are more then 20 different tools available (see Griffiths et al., 2005 for a discussion and overview). Several authoring environments are available that support the development of the learning design XML files and zip-files. To be mentioned are Reload (2005), MOT+ (Paquette *et al,* 2005), Ask-LDT (Karampiperis & Sampson, 2005) and CopperAuthor (2005). Furthermore there is the CopperCore engine (Vogten & Martens, 2005; Martens & Vogten, 2005) that can interpret and set up learning design files. CopperCore however does not provide a user-interface (a so-called 'Learning Design Player'). A player adds a user-interface, but also integrates services (chats, forums, etc.) that are referred to in the learning design. Furthermore it includes an administration module to import/export learning design packages, to create a run of a unit of learning, to add persons, to put persons in the correct roles and to connect to external systems (e.g. student administration, portfolio systems, etc.).

There are several prototypical players available, but most of them are still too underdeveloped to use in actual practice. Also several integrated systems (Alfanet: Van Rosmalen et al., 2005; LAMS: Dalziel, 2003) are available, however these are or very prototypical (Alfanet) or do not yet conform to the IMS Learning Design specification (LAMS). Last but not least, there is a growing set of examples and test units of learning available at moodle.learningnetworks.org that can be used to demonstrate the different possibilities of learning design. The challenge for the coming period will be to build a player and to integrate some of the tools into a platform that can be used to use learning design courses in actual practice. Given the enormous amount of activity in the field, we can expect that this will be realised in the next year. One factor of importance will be a new large EU funded project, called TENCompetence (2005) that will have as one of its main tasks to build an open source learning design platform that can be used in lifelong competence development.

Overview of Research Issues

The papers in this special issue can be classified in the following three themes:
1. Learning Design & Ontologies
2. Developing Learning Designs: methods, patterns and integration with other standards
3. Learning Design Engines

I will now discuss each topic and the papers within that topic.

Learning Design & Ontologies

As stated above, the Learning Design specification contains a conceptual model, or better an ontology, of the teaching-learning process (see figure 1). The tradition of IMS is to use XML schema bindings for all implementations. This has its advantages and disadvantages as is explained in the papers of Knight *et al* and Amorim *et al.* Both papers present the idea of using a new binding: OWL instead of XML schema. Knight *et al* use this new binding to unify the description of learning designs and learning objects to increase the level of reusability. The idea is to use a three part model: an ontology for learning design (called LOCO), an ontology for learning objects (ALOCoM) and an ontology for the intermediate level between learning design and learning objects (the learning object contextual model, LOCO-Cite).

The paper of Amorim *et al* elaborates a precise definition of the learning design ontology. They argue that the informal description of the information and behavioural model increases the complexity for programmers, because they are not educational specialists. This could invoke unnecessary errors in the technical implementations. Their proposal is to replace the XML schema's with an explicit and formal ontology language (OWL). The authors provide a modelling example (description of the Jigsaw Methodology).

In the discussion at the workshop, one of the main problems identified was that a new binding like OWL could have the danger of increasing the complexity of the specification instead of decreasing it. This can be justified when some common identified problems have been solved by re-representing the specification. The work on Learning Design ontologies is however in a too early-days stage to answer this question definitely. A further remark could be made on the positioning of ontologies in the field of Learning Design. Providing an alternative binding is one type of use, but another could be even more advantageous: the use of ontologies to represent learning design knowledge. Learning Design captures a large variety of pedagogical models and ideas that a learning designer applies. The knowledge of the learning designer himself is however not captured in Learning Design: it only represents the result. An idea would be to make a set of different ontologies that represent learning design knowledge for each pedagogical model, e.g. an ontology for the application of problem-based learning principles. Such an ontology could then be used to build software agents that apply these ontologies to help learning designers to develop units of learning according to a specific pedagogical model.

Developing Learning Designs: methods, patterns and integration with other standards

The next theme contains five papers in this special issue: Hernández-Leo *et al*, Van Rosmalen *et al*, Pawlowski *et al*, Paquette *et al* and Bailey *et al.* Each of the papers addresses a means to support learning designers to develop adequate learning designs, using the IMS Learning Design specification.

The first paper of Hernández-Leo *et al* looks at the idea of using patterns to support the development of collaborative designs. The authors developed the Collage tool, that is based on the Reload editor. The tool helps learning designers to develop the rather complex collaborative learning scenario's by reusing and adapting patterns, called Collaborative Learning Flow Patterns. In this special issue this is the only paper that deals with patterns. However in the workshop we had presentations of 5 papers related to patterns. One of the issues was the definition of patterns itself. After a discussion we agreed upon a description that is similar to the one found in Wikipedia (http://en.wikipedia.org/wiki/Pattern): 'a *pattern* is defined as a form, template, or model (or, more abstractly, a set of rules) which can be used to make or to generate things or parts of a thing, especially if the things that are generated have enough in common for the underlying pattern to be inferred or discerned, in which case the things are said to exhibit the pattern. The detection of underlying patterns is called *pattern recognition*.' The next problem identified is how patterns can be developed. The first approach is called an inductive method and is based on pattern recognition (Brouns *et al.,* 2005): the idea is to compare a series of Learning Design coded courses to identify the presence of a set of underlying reoccurring XML constructs. The second approach is referred to as a deductive approach and is used in the development of 'pedagogical patterns' (Goodyear *et a.l,* 2004). In this case, the patterns are developed by experts, based on their interpretations of teaching practice. The idea of learning design patterns and the possibility to recognise them automatically with pattern detection algorithms is a new field of work that is worthwhile to elaborate in the future. Also, the *use* of patterns (including tooling) by learning designers has to be explored further.

The paper of Van Rosmalen *et al* decribes the result of the EU-funded Alfanet project. This project offered one of the first implementations of IMS Learning Design in a learning management system. The focus of the project was on adaptive learning designs. Tools like CopperCore are developed in the context of this project. It was also the first project that tried to develop a prototypical platform that was fully based on a large set of learning technology standards and specifications. They used and integrated among other things: IMS LD (2003), IMS QTI (2003), IMS CP (2004), IMS MD (2001) and IMS LIP (2001) to realise adaptive learning designs. The paper presents a model that enables a structured, integrated view on (the support for the) development of adaptive learning designs. They report pilots with users who use the models and the tools. The project identified two major issues: first of all that the 5 specifications used are not really harmonized to work together. Some of these issues have already been taken-up by IMS to change some of the specifications. For instance, IMS QTI has been changed recently to integrate better with IMS Learning Design. Another issue, not unique for this project, is the problems with the usability of the tools. The different standards impose a rather high complexity for the users. One of the future problems to be solved is how this can be presented to the user in a user-friendly and flexible way.

The paper of Pawlowski *et al* deals with the problem to make learning design knowledge reusable. This is related to the earlier discussion of ontologies and patterns. The authors argue that in order to make learning design knowledge reusable, information about the context of use and about the experiences of users should be added to the learning design. They developed the Didactical Object Model in the context of the German Standards Body (DIN) to be used in conjunction with IMS Learning Design. They report some first experiences with the use of this model.

The paper of Paquette *et al* discusses the use of a graphical modelling method and tool to support learning designers to develop units of learning. They explain that the coding of a unit of learning is the result of a knowledge engineering process where knowledge, competencies, learning design and delivery modes are constructed in an integrated framework. The authors present a graphical language (MOT graphic language) and a knowledge editor adapted to IMS Learning Design.

A major reoccuring topic addressed by this paper is the use of a graphical representation of learning designs (see also Giacomini Pacurar *et al*). At the moment there are many proposals, e.g. the once build into the LAMS and ASK-LDT products and the proposal to use the standard language BPMN (2005). One of the suggestions for future work is to develop a standard graphical meta-language for Learning Design that has an explicit translation to the IMS Learning Design specification. This works preferably in both directions: from visual notation to XML and from XML to visual notation, however the latter could be quite complicated without additional constructs added to the XML.

The last paper in this theme is from Bailey *et al*. It is an example of a pedagogical approach and tools that has been developed to support teachers and learning designers to develop effective learning designs. The problem is solved without using the IMS Learning Design specification as a reference. Later on the approach is mapped to IMS Learning Design. They identify several issues with the specification, like the absence of learning objects and prerequisites elements in the learning activity structures of the Learning Design specification (this is a known issue and will be corrected in one of the next revisions of the specification). Looking at this paper from a distance it does the following: it solves a pedagogical problem and then, for interoperability purposes, it translates the approach to IMS Learning Design. This is opposite to approaches where Learning Design is taken as a starting point to solve educational problems. Because Learning Design is designed to represent any pedagogical approach (see requirement 2), my personal preference would be to follow the first approach: concentrate on the educational problem, find solutions and implement the solutions in IMS Learning Design. This has the advantage that people are not distracted from the problem itself by all the possibilities that the specification itself has to offer. At the other hand, knowing the specification (especially the conceptual model) can also help in structuring the problem and to use the same terminology in the learning design community.

Learning Design Engines

This last theme addresses the development and use of learning design runtime engines, and it includes four papers: Zarraonandia *et al*, Weller *et al*, Klebl and Giacomini Pacurar *et al*.

The paper of Zarraonandia *et al* addresses an issue that is related to the fact that IMS Learning Design specifies a unit of learning in *design-time* and not in *run-time*. Each unit of learning is instantiated to create a run for that unit of learning, i.e. by providing a start-date, adding users to it, and by assigning users into roles. The same unit of learning can be instantiated as many times as needed for new users. This increases the reuse possibilities considerably (see Tattersall *et al*, 2005), but also brings some additional complications. One of these complications is the question how runtime adaptations should be dealt with. In essence there are several possibilities depending on the kind of change that is made to the run of the unit of learning: a) changes are made to the unit of learning, the run of the unit of learning, or only for particular users or roles in a unit of learning; b) these changes should be propagated to all the current runs of the unit of learning that run in parallel; c) these changes should be propagated to the (design-time) unit of learning itself.

The paper of Zarraonandia *et al* discusses these different adaptations, and concentrates on the adaptations that do not propagate to the design-time unit of learning (1, 2 & 5). They created an adaptation to the CopperCore engine and demonstrate its use in several examples.

Weller *et al* addresses the question how to integrate Learning Design into an e-learning environment that consists of a number of services/components that interact with Learning Design (e.g. tests, forums, chats, portfolio's). The paper describes the work on the SLeD project that aims to develop a Learning Design Player, using the CopperCore engine. The architecture of SLeD is presented to solve the problem how to integrate services into a Learning Design Player. The solution is somewhere in between a generic solution and an application specific solution, however the idea was to use generic service descriptions as a universal acid. The pro's and con's are discussed. This paper is also related to the work of Van Rosmalen *et al,* who also integrated a variety of services in a similar way in the Alfanet project (see description above).

Klebl reports on an empirical review of Learning Design using an implementation in Moodle (Dougiamas & Taylor, 2002) in a university context. The basic questions he had were as follows: a) can Learning Design be used in blended learning approaches (related to requirement 1 of Learning Design, see above) and b) is the solution provided usable from a human-computer interaction perspective. He concludes as follows: “Though limited in scope, the successful implementation of IMS Learning Design in higher education proves the possibility to support mixed mode learning scenario's.” He furthermore notes that extending Learning Design with a kind of 'activity situation' where teachers and learners interact intensively could solve some restrictions he found. In the current specification, these strict division of activities of learners and teachers leads to a complex and redundant description of the teaching-learning process.

The last paper in this theme is from Giacomini Pacurar *et al*. They created a web-application that can be used by teachers to generate course structures, to edit pedagogical content and to instantiate, run and administer their courses. Part of the tool is a graphical editor for IMS Learning Design. They report on the development of the so-called 'netUniversité' environment and provide an example of a course website created with the application. The paper is related to the idea that is also discussed by Bailey *et al* to support the teacher (instead of a specialised learning designer) to use Learning Design. This issue has raised some interesting discussions: can teachers (or even learners) act as designers, and if so, what support should they be given to develop effective designs? Because Learning Design is often compared to musical notations, this issue is compared to the question whether musicians can be (or: should be) composers?

Conclusions

This special issue aims to provide an overview of the current work in the field of Learning Design. Eleven papers were analysed on the basic topics that are currently the focus of research. In summary these issues are the following:

1) The use of *ontologies* and semantic web principles and tools to:
    a) create a new, and more precise binding for Learning Design;
    b) integrate learning objects and learning designs;
    c) to represent specific pedagogical approaches (learning design knowledge);
    d) to build software agents that operate on the learning design knowledge to support in the development of units of learning.
2) The use of learning design patterns:
    a) to support learning designers to develop specific learning designs (e.g. collaborative designs, adaptive designs);
    b) that are automatically detected (pattern recognition) in Learning Design coded units of learning;
    c) to capture best practices and learning design knowledge (relates to ontologies ad c and d).
3) The development of Learning Design *Authoring and Content Management* Systems, including the following issues:
    a) The development of a (standard) graphical notation for learning designs;
    b) How to support the reuse of Learning Design Knowledge and Learning Design Packages;
    c) The development of learning design specific tools to support teachers in a specific context;
    d) The question how learning designers should be supported with tools and how teachers should be supported with tools (the teacher as a designer);
    e) The integration of learning design and assessment editors in a single authoring environment.
4) The development of *Learning Design Players,* including the following issues:
    a) How to integrate the variety of specifications (eg, IMS LD, IMS QTI, SCORM, IMS LIP) and the connections to other systems in an e-learning infrastructure (student administration, portfolio systems, financial systems) into a single, easy to use learning environment.
    b) How to instantiate and integrate communication and collaboration services that are called by a Learning Design. Eg, forums, wiki's, chats; are generic service oriented architectures suitable to do the job? At what costs?;
    c) How to design a usable, powerful and flexible user-interface for a Player environment?
    d) How to integrate Learning Design into existing Learning Management Systems (like Moodle, Blackboard and LAMS)?
    e) How to integrate Learning Design Authoring Systems and Learning Design Players, including the question how to deal with runtime adaptations?
    f) How to use an integrated set of Learning Design tools in an integrated way in a variety of settings (e.g. in universities, training, blended learning).

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An Ontology-Based Framework for Bridging Learning Design and Learning Content

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ABSTRACT

The paper describes an ontology-based framework for bridging learning design and learning object content. In present solutions, researchers have proposed conceptual models and developed tools for both of those subjects, but without detailed discussions of how they can be used together. In this paper we advocate the use of ontologies to explicitly specify all learning designs, learning objects, and the relations between them, and show how this use of ontologies can result in more effective (semi-)automatic tools and services that increase the level of reusability. We first define a three-part conceptual model that introduces an intermediate level between learning design and learning objects called the learning object context. We then use ontologies to facilitate the representation of these concepts: LOCO is a new ontology based on IMS-LD, ALOCoM is an existing ontology for learning objects, and LOCO-Cite is a new ontology for the learning object contextual model. We conclude by showing the applicability of the proposed framework in a use case study.

Keywords

Learning design, Learning objects, Ontologies, Reusability, Learning content

Introduction

Specifying reusable chunks of learning content and defining an abstract way of describing designs for different units of learning (e.g. courses, lessons etc.) are two of the most current research issues in the e-learning community. First, we have the research in the field of learning objects. Among many important definitions of learning objects such as (Barrit et al., 1999; Richards, 2002; Wiley, 2002) we refer to a very broad definition (Duval, 2002): A learning object is any entity, digital or non-digital, that can be used, re-used, or referenced during technology-supported learning. This definition was used for defining the IEEE LSTC standard for Learning Object Metadata (LOM). In addition to this vague definition, learning objects suffer from a lack of ability to semantically express relations among different types of objects in the context of use in an educational setting (Koper, 2001). Accordingly, to overcome these issues, we have a second group of efforts referred to as learning design (LD) that can be defined as an application of a pedagogical model for a specific learning objective, target group, and a specific context or knowledge domain (Koper & Olivier, 2004). As a response to these activities there is an initiative to define Learning Design-related recommendations at the IMS (IMS-LD-IM, 2003).

Although both of the aforementioned initiatives are interrelated, some questions still have to be answered, such as: How can we employ just some specific parts of a learning object, rather then the learning object as a whole in a specific learning design?; How can we reuse the same learning design in different contexts with different learning objects?; How we can personalize the content of the same learning object according to learners' models in the same learning design?; and How can we develop more extensive learning object and learning design search and ranking services?

In this paper we advocate the approach that ontologies and Semantic Web technologies can offer a solid solution to these semantic issues (Kaykova et al., 2005), because an ontology gives an explicit definition of the shared conceptualization of a certain domain. In fact, the ontology constrains the set of possible mappings between symbols and their meanings (Stojanović et al., 2001). The benefits stemming from the use of Semantic Web technologies in the e-learning context can be recognized in the following services: discovery of resources; composing new resources compliant to the requirements of a particular learner out of the available resources; and user-resource automatic interaction dynamically adapted to the features of the particular user (Panteleyev et al., 2002).

Following these ideas, this paper proposes an ontology-based approach to integrate learning designs and learning objects. First, we develop a conceptual model that differentiates between learning objects and learning object contexts in order to increase the level of reusability of learning designs. Next, to express this model, we create a Semantic Web ontology called Learning Object Context Ontology (LOCO) based on the IMS Learning Design Information Model (IMS-LD-IM, 2003). We use the ALOCoM ontology, a current EU ProLearn NoE effort to define learning object content structure (Jovanović et al., 2005a). Relying on the conceptual model we defined as well as those two ontologies, we identify and explicitly specify relations between ontology classes. Those mappings are also represented in a separate ontology we call LOCO-Cite. On top of those mappings we discuss possible use cases and benefits of the proposed approach.

A brief overview of learning objects and learning design

This section reflects basic concepts and relevant state of the art efforts of both learning objects and learning design.

Learning objects

The broad definition of "learning object" reflects the two very different communities who have an interest in reusable learning resources. The military-industrial community with its heritage in computer-based learning has a strong interest in well-defined content designed in small interactive chunks to address specific learning objectives. This precision is reflected in the US military's ADL SCORM specification (ADL, 2005). On the other hand, the education community reflects an idiosyncratic potlatch of freely-contributed web-based content demonstrating creativity in the use of multi-media and usually broader learner outcomes focused as much on intellectual development as content. While even these sweeping generalizations may be difficult to apply, they do reflect the complexity facing those developing, using and re-using learning objects. Reuse can occur by either prescription/inclusion of the learning object in a course of study, or by using the learning object as an instructional design template - i.e. studying and re-using the instructional approach with new content. It is in this latter use that learning design can be of particular benefit as the instructional design of an object can be made more explicit so that it may be readily adapted for new instructional situations (Sheth et al., 2005). In an effort to promote the locating and re-use of learning objects much effort has recently gone into the interconnection of the repositories or data-warehouses in which learning objects are stored (Richards & Hatala, 2005). While most search and retrieval is based on content descriptions, an explicit learning design vocabulary may shortly enable searching for objects by pedagogical models or learning intentions (Carey et al., 2002).

Currently, the Learning Design world is pulled between the interests of macro and micro instructional design. With its roots in EML (Koper, 2001), a system designed for the mass production of distance education courses, Learning Design has broad applicability in describing the coordination of learning events. Yet at the same time, many of the examples in the best practice guide detail smaller units of learning such as the Versailles cooperative learning scenario. Clearly as LD use increases and it is applied in different scenarios we will see a fleshing out of good examples in both these areas, hopefully with convergence in the language that we use to describe and classify these examples. This is a role for ontologies. Each ontology provides the vocabulary (or names) for referring to the terms in a subject area, as well as the logical statements that describe what the terms are, how they are related to each other, how they can or cannot be related to each other, as well as rules for combining terms and relations to define extensions to the vocabulary (Hendler, 2001). With ontologies we can formalize our conceptual models and automatically perform semantic operations such as searching, and selecting.

This problem has already been addressed in the LO community by proposing ontologies to formalize LO content models (Verbert et al., 2004; Verbert et al., 2005). Essentially, LO content models, providing more precise definitions of LOs, strive to eliminate the vagueness of the LO concept posed by its official definition (Duval, 2002). A deeper insight into LOs structure, provided by content models, facilitates (semi-)automatic repurposing of LO components. The result of that initiative in an Abstract Learning Object Content Model (ALOCoM) (Verbert et al., 2004), the ALOCoM ontology developed on top of that model (Jovanović et al., 2005a), and a set of tools for transforming from/to current learning object formats such as slide presentations (Verbert et al., 2005). We describe this effort in detail later in the paper. Finalizing this section, note also that there are some types of learning objects that are too complex to be simply represented as a sum of their components (e.g. image files).

Learning Design

In this section we list several approaches to expressing learning design and emphasize their advantages and weakness in order to get a greater picture about the present research in the field of learning design.

Koper and Olivier (2004) define learning design as an application of a pedagogical model for a specific learning objective, target group, and a specific context or knowledge domain. An important part of this definition is that pedagogy is conceptually abstracted from context and content, so that excellent pedagogical models can be shared and reused across instructional contexts and subject domains. An example of this is the Learning Activity Management System (LAMS) "What is greatness?" (Dalziel, 2003). In this example, students participate in a series of group discussion activities to try to define greatness. The same sequence of activities can easily be reused by changing the question to "What is jazz?" The subject domain (historical figures or music history) and the instructional context (grade 7 history or grade 10 music) are of peripheral consequence to the pedagogical information (who will do what activities and assume which roles, in what order, and why). The "What is greatness/What is jazz" example is distinct from the well known EML example, "Learning to listen to jazz" (Hummel et al., 2004), that addresses the issue of personalization of learning content and processes.

Learning designs can be represented graphically or formalized according to an information model. Our limited usability tests have indicated that users prefer a graphical representation to conceptualize the learning design, while software systems require precise formalization. No standard has yet been established for the graphical representation of learning designs; however, there are many possible methods (Richards, 2005). LAMS, although not fully IMS LD compliant, makes use of a UML-based approach (Dalziel, 2003), as does (Tattersall, 2004). The MOTPlus editor (Paquette, 2004) uses knowledge representation theory as a basis for graphic representation of learning designs.

The IMS-LD specification provides an information model and XML binding that facilitates the conceptualization and formalization of a learning design for the purposes of standardized information exchange and integration with software systems (IMS-LD-IM, 2003). IMS-LD supersedes previous specifications such as Educational Modeling Language (EML) (Hummel et al., 2004) and adds more flexibility to represent diverse pedagogical models. IMS-LD Levels A, B, and C are currently implemented in the CopperCore run-time environment (Vogten & Martens, 2003) which is an engine for running IMS LD. The Reload (Reload, 2005) and CopperAuthor (CopperAuthor, 2005) editors are fully compliant with IMS-LD and use the CopperCore engine, while the MOTPlus editor can export XML that is compliant with IMS-LD Level A. The Reload editor also allows the creation of IMS metadata, as well as IMS and SCORM content packaging. CopperAuthor is closely integrated with the CopperCore run-time environment, offering a convenient user interface to publish and validate learning designs during the authoring stage. MOTPlus offers a unique graphical interface for "drawing" learning designs, based on meta-knowledge representation of a different information model from IMS LD (Paquette, 2004).

Although using XML enables the sharing of learning designs among different IMS-LD based tools, it is syntactic interoperability that basically validates the grammatical correctness of shared models (Decker et al., 2000). However, to achieve an additional (semantic) level of interoperability we need another solution. In fact, this problem has been already recognized in the learning design community, and a few authors have already proposed the use of ontologies. (Buzza et al., 2004) report that the lack of a shared vocabulary is a major obstacle in cataloguing and searching for learning designs in a repository. Furthermore, Koper and Olivier (2004) describe how integration and coordinated use of ontologies will be a key area of future development in learning design. The establishment of shared vocabularies will be a key part of the creation and acceptance of a learning design ontology. Finally, the IMS-LD specification should allow for the flexible definition of the relations among learning designs and learning content (i.e. learning objects) in order to enable the reuse of the same learning design with different learning content.

We propose to address these points to strengthen the current IMS-LD specification by developing an ontology that will facilitate the reusability of learning designs and learning objects. The ontology must have a clear conceptual framework that minimizes complexity for developers while maintaining flexibility.

Connecting Learning Designs and Learning Objects

After briefly summarizing basic concepts of both learning objects and learning designs in the previous two sections, we propose a conceptual framework for connecting learning designs and learning objects. We start from the premise that learning design offers tremendous potential for content repurposing. Starting with some educational content in the form of learning objects (including images, text, and animations) and some web-based learning support services (chat, messaging, multiple choice tests), the learning designs can choreograph the order in which the content will be presented, how it will be integrated in learning support services, how it will be sequenced and how it will be assigned to learners in a lesson. Conceptually, this can be pictured as pulling learning objects from a repository and using the learning designs to integrate the LOs into activities that involve learners. The IMS-LD specification provides the capability to reference external learning objects through URI property elements and keep a clear separation between the learning design and the content being referenced.

When learning objects are incorporated into a learning design, there may be many possible learning objects to choose from. A course author will be able to automatically search through learning object repositories for suitable content. Ideally the learning objects will contain metadata that will help the course author to identify the most suitable content for a specific purpose. However, this assumes that the learning object will have a single instructional context for which it can be useful. From the standpoint of learning object reuse, it would be advantageous for a learning object to have many different uses, so that expensive multimedia content elements could be reused in as many different learning objects as possible. A learning object that contains pictures of the Acropolis could be used for both a grade 10 art course and a university-level history course. The ALOCoM ontology for repurposing learning object content was designed to facilitate this type of repurposing (Jovanović et al., 2005a). As shown in Figure 1, fragments of content are packaged into learning objects which are incorporated into activities for learners.

Figure 1 illustrates this process in more detail; a learning design is assigned a Method, which will consist of one or more Plays. A Play will be made up of one or more Acts in sequence. Each Act, with its associated Role-parts, Activities, and Environments will utilize a learning object. The learning object may be either static or dynamic. A static learning object is made up of fixed content that has been tightly integrated at design time, making it difficult or impossible to reuse the learning design with different content. Examples of a static learning object would be an interactive Macromedia Flash tutorial or a MPEG movie. A dynamic learning object is one that is constructed out of loosely-bound content objects and has the flexibility to allow for run-time content-repurposing, such a web page. Many learning objects will fall somewhere between the two extremes, but learning objects that are more dynamic will be more suitable for use in this ontology because they maximize the ability to choose content based on context.

The best way to facilitate the integration of learning objects into a learning design without compromising reusability is to treat contexts for LOs (learning object contexts - LOCs) as distinct entities from the LOs themselves, as shown in Figure 2. The LOs exist independently from any presupposed instructional context, meaning that they can be used in any situation in which a course author finds them useful. Within the extensive domain of different instructional contexts, many different LOCs can be created and associated with LOs in a many-to-many relationship. If a course author decides that a particular LO is useful in a grade 7 biology course, a new context object is created associating that LO with that specific context.

Note also that the purpose of LOCs is not to have another group of objects in learning technologies. In fact, the present learning object practice has already recognized that learning object metadata such as IEEE LOM is not flexible enough to fully support learning objects reusability. For example, the eLera learning system proposed introducing an intermediary metadata level besides learning objects metadata in order to keep track of the quality of the learning objects with information such as reviews, comments, or recommendation for future use (Li et al., 2004). This learning object quality information can by created by those who did not create the learning objects nor even used them. Accordingly, such information is not suitable to be kept as a part of learning object metadata.

From a programming perspective, the best way to facilitate LOC is as a distinct class of object from the LOs themselves. In terms of relation databases, the concept of a LOC closely resembles that of a linking table in a relational database. A linking table (Ramakrishnan & Gehrke, 1998) is used for formalization when two objects are associated in a many-to-many relationship. An implication of this type of relationship is that neither object "owns" the other. This is the kind of metaphor we are aiming for with an LOC: a learning design does not "own" a learning object since the learning object could be reusable in many other situation. If we annotate the learning object with context information such as the prerequisites and competencies applicable to the learning object in a grade 7 biology course, we establish an implied ownership relation. In this case, the learning object can be owned by learning designs that target seventh grade biology or an equivalent. If we instead choose to include the information in the learning design, the learning design will be tied to a particular context, which reduces its reusability. Looking again at Figure 2, we see the domain of instructional contexts. The shaded background represents all of the possible ways a given learning design could be used in practice. The learning objects remain outside this domain, so that they can be used by other learning designs in other contexts. In fact, a new LOC is created by associating that LO with that specific context.

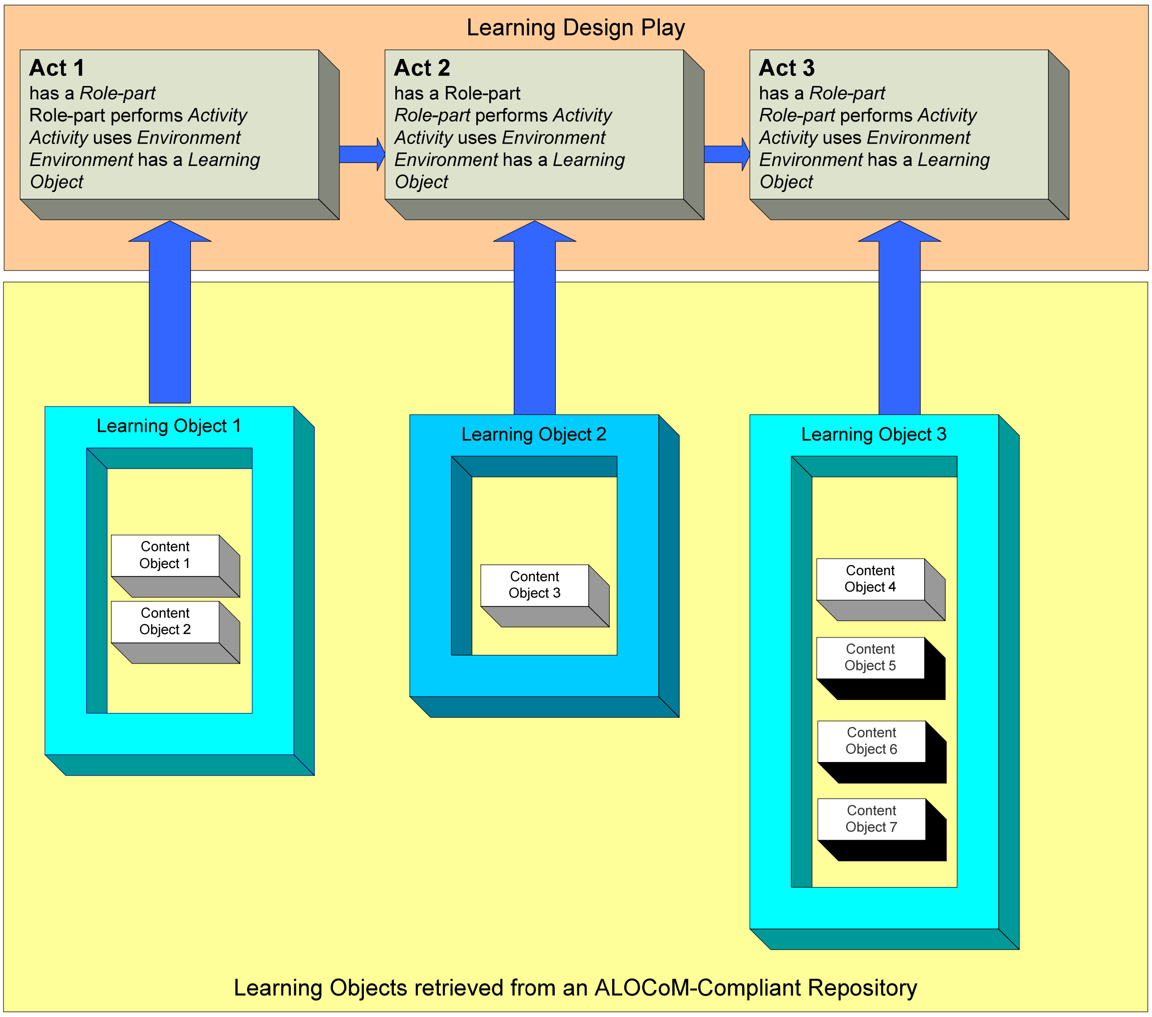

Figure 1. Incorporating digital content into learning designs

Supposing an instructional designer has created a learning design for a grade 7 biology course that includes several activities, each referencing a learning object or service, and defines roles for learners and staff according to the problem-based learning pedagogical model. Included in that learning design is implicit information about what types of learning objects work well when used as activities in a problem-based learning structure, and conversely, that the problem-based learning model is a good model to use these learning objects within. An examination of the learning objectives, prerequisites and roles associated with this activity will help determine similar contexts in which the learning objects can be used.

A learning object context (LOC) would contain data that is specific to a single learning object in a particular instructional context. Learning objectives, competencies, and evaluation would be stored in this object as opposed to the learning object, so that the learning object could be associated with multiple LOCs and different learning objectives, competencies, and evaluation. The LOC could also contain context-specific subject domain ontology information, since the specification of subject domain annotations will be dependent of the context. Table 1 lists the information that should belong to learning design, LOC, and LO according to the proposed model in Figure 2.

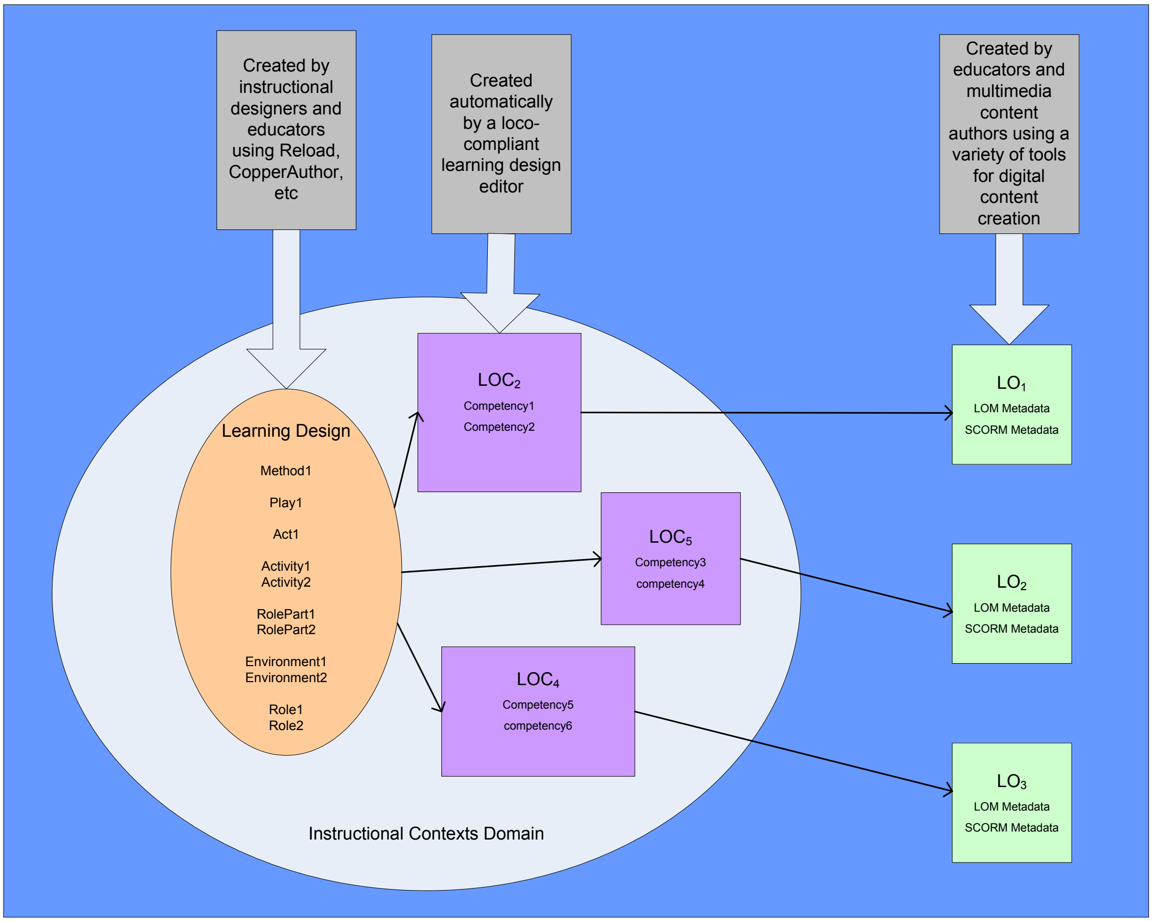

Figure 2. Learning Object Contexts: a conceptual model

*Table 1***.** Information properly associated with a learning design, LOC, and LO

Learning design	**Learning object context**	**Learning object**
Created by: Instructional designers and educators	**Created by:** Anyone who reuses a learning design with new learning objects	**Created by:** Educators, multimedia production companies, or software agents through ontology-based content repurposing (ALOCoM)
How created: IMS-LD-compliant learning design editors such as Reload and CopperAuthor	**How created:** Integrated into future tools so as to abstract LOC's from the user and make the process as transparent as possible	**How created:** Virtually any method by which digital content is created
Associated Information: • Lesson Structure – how the activities are sequenced • Roles – how users will interact in single and multi-user learning designs • Pedagogical Models – instructional theory guiding the lesson structure, roles, and method of evaluation • General Learning objectives for chosen methods (not related to context). For example, the learning objectives associated with all problem-based learning.	**Associated Information:** • Content-specific learning objectives and prerequisites • Competencies and specific evaluation of attached competencies • Subject domain annotations particular to a learning situation (e.g. Grade 7 biology terminology) • Quality of experience and suggestions for better use (lessons learned)	**Associated Information:** • LOM and/or SCORM metadata describing the digital resources • Domain specific ontology-based annotation (they can be regarded as a part of LOM as well)

The learning design will be constructed by creating a sequence of activities for learners. Each activity will be associated with a learning object context and a learning object. The learning design will specify roles, sequencing and logistical information, and pedagogical information. The learning design can be reused with different learning objects, and the learning object context will provide clues as to what types of learning objects would be suitable replacements. This will facilitate the adoption of learner modeling techniques and adaptivity (personalization).

The description of a learning design in Table 1 is based on the idea of a generative pattern, a term borrowed from object-oriented software design (Gamma et al., 1995), and is based on the notion that the underlying structure of the design can be abstracted from its implementation, and later be used to instantiate concrete instances of the pattern. This relates closely to the goal of learning design reuse described by (Koper, 2005), to harness the "underlying learning design that is more generic than the practice itself". In the next section we explain how we formalize the proposed conceptual framework using ontologies.

Mapping conceptual model to ontologies

In order to provide an explicit specification (i.e. ontology) of the conceptual model depicted in *Figure 2* we identify the need for the following three ontologies: a) an ontology of learning object content, b) an ontology of learning design, and c) an ontology connecting those ontologies. In the rest of the section we describe each ontology in detail as well as illustrating their usage for representing LDs, LOCs, and LOs.

a) ALOCoM - Ontology of learning object content

Having looked at several content models (e.g. Learnativity, SCORM content aggregation model, CISCO RLO/RIO, NETg), we decided to use the ALOCoM, a recent EU ProLearn NoE effort (Verbert et al., 2004). The ALOCoM was designed to generalize all of these content models, to provide an ontology-based platform for integrating different content models, and to enable (semi-)automatic reuse of components of LOs by explicitly defining their structure (Sheth et al., 2005). In this paper we refer to the ontology built on top of that model (Jovanović et al., 2005a) called the ALOCoM ontology. Actually, we use a revised ALOCoM ontology (Jovanović et al., 2005b) divided into two different parts:

- *ALOCoM Content Structure* ontology enabling a formal representation of LOs decomposed into components;
- *ALOCoM Content Type* ontology defining the educational role of LOs and their components.

Both ontologies are developed in OWL (Bechhofer et al., 2004). The ALOCoM Content Structure ontology distinguishes between content fragments (CFs), content objects (COs) and learning objects (LOs). CFs are content units in their most basic form, like text, audio and video. These elements can be regarded as raw digital resources and cannot be further decomposed. COs aggregate CFs and add navigation. Navigational elements enable sequencing of content fragments in a content object. Besides CFs, COs can also include other COs. LOs aggregate COs around a learning objective. In Figure 3 we show the top-level ontology concepts. Note also that the ontology defines aggregational and navigational relationships between content units.

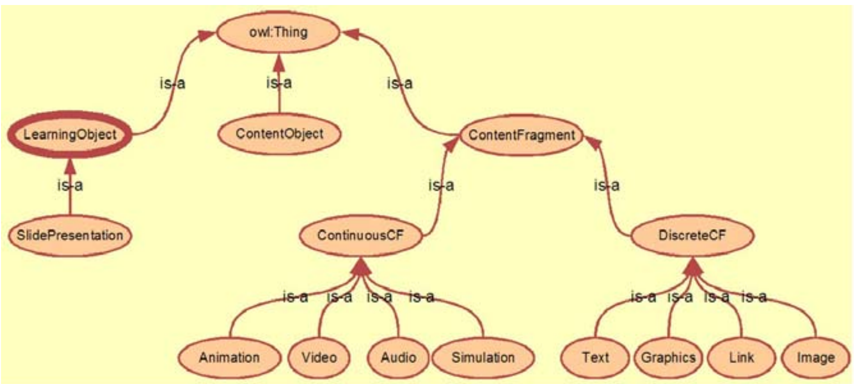

Figure 3. The top level concepts of the ALOCoM Content Structure ontology

The ALOCoM Content Type ontology is also rooted in the Abstract LO Content Model and has CF, CO and LO as the basic, abstract content types. However, these concepts are now regarded from the perspective of educational/instructional roles they might have. Therefore, concepts like Definition, Example, Exercise, Reference are introduced as subclasses of the CO class, whereas concepts such as Tutorial, Lesson, Test are some of the subclasses of the LO class. The development of this ontology was mostly inspired by a thorough examination of existing LO Content Models (Verbert et al., 2004) as well as by a closely related work presented in (Ullrich, 2005).

Note also that both the ALOCoM ontologies are organized as extensible infrastructures that can be further extended with new LO types or content structure elements. Another beneficial point for using ALOCoM is an extensive development of tools able to represent widely accepted formats of LOs (e.g. slide presentation) using ALOCoM ontologies (Verbert et al., 2005).

Having in mind all the aforementioned facts, the ALOCoM ontologies seem to be a very suitable solution that can be combined relatively easily with ontologies describing learning designs based on the IMS-LD specification. Using the capacity of the ALOCoM ontologies to reuse components of LOs, we will be able to reuse learning design with just the components of LOs that are relevant to the new learning design usage scenario. Since we have information about LO components, the same LO can be better personalized according to the learners' specific needs, preferences and styles (e.g. learning using examples rather than formal definitions) when using the same learning design.

b) LOCO - an ontology compatible with IMS-LD

The IMS-LD Information Model and XML binding is the specification for Learning Design (IMS-LD-IM, 2003). As many of the tools and editors for learning design will be developed around this specification it is important to maintain compatibility. The IMS-LD Information Model contains UML diagrams that we used as a blueprint for the creation of an IMS-LD-based ontology named the Learning Object Context Ontology (LOCO). To create the LOCO, we needed to make some changes to the Information Model (IMS-LD-IM, 2003) in order to conform to established good-practice recommendations for ontology design (Noy & McGuinness, 2001), and to resolve some ambiguities and inconsistencies in the information model. We have already reported these inconsistencies in detail in (Knight et al., 2005). To date the LOCO only addresses IMS-LD Level A.

We decided to build the LOCO in the OWL language (Bechhofer et al., 2004) as it is a W3C recommendation for the Semantic Web ontology language. We also used the Protégé OWL plug-in (Knublauch et al., 2004), an OWL ontology editor, to develop the LOCO. Figure 4 shows the LOCO's *is-a* class hierarchy we developed using Protégé. The main emphasis is on the *Learning_object* class since our goal is to make a connection between learning content (e.g. represented in the ALOCoM ontology with the *LearningObject* class) and learning design (i.e. LOCO). In the LOCO, the *Learning_object* class is a subclass of the *ResourceDescription* class. Accordingly, the *Learning_object* class inherits the following properties from the *ResourceDescription* class: *item*, *metadata*, *title*, and *hasResource.*

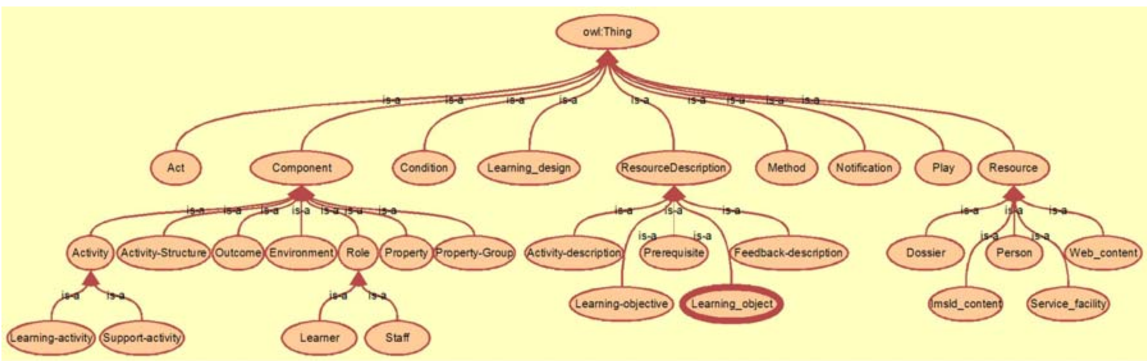

Figure 4. A Protégé screenshot representing a part of class hierarchy of the LOCO

Let us describe the *hasResource* property in order to illustrate one of the class properties in the LOCO. Initially, the range of the *hasResource* property is the *Resource* class. However, according to the IMS-LD specification we additionally have to restrict its range, so that the range is a union of the *web_content* and *Imsld_content* classes (i.e. *hasResource* on the class *Learning_object* can take values that are instance of *web_content* and

Imsld_content classes). This restriction in Protégé OWL plug-in is expressed in a Description Logic (Baader et al., 2002) like form:

$$\forall\ hasResource\ (web\_content \sqcup Imsld\_content)$$

In Figure 5 we give the final definition of the *Learning_object* class expressed in OWL/XML syntax.

```
<owl:Class rdf:ID="Learning_object">
        <rdfs:subClassOf>
                <owl:Restriction>
                        <owl:onProperty>
                                <owl:ObjectProperty rdf:ID="hasResource"/>
                        </owl:onProperty>
                        <owl:allValuesFrom>
                                <owl:Class>
                                        <owl:unionOf rdf:parseType="Collection">
                                                <owl:Class rdf:ID="web_content"/>
                                                <owl:Class rdf:ID="Imsld_content"/>
                                        </owl:unionOf>
                                </owl:Class>
                        </owl:allValuesFrom>
                </owl:Restriction>
        </rdfs:subClassOf>
        <rdfs:subClassOf>
                <owl:Class rdf:ID="ResourceDescription"/>
        </rdfs:subClassOf>
</owl:Class>
```

Figure 5. OWL/XML definition of the Learning_object class in the LOCO

c) LOCO-Cite – an ontology for bridging the learning object content and learning design ontologies

The final step is to create an ontology that serves as a bridge linking the LOCO and ALOCoM ontologies according to the learning object context conceptual model shown in *Figure 2*. Because this makes an explicit reference to a specific learning object, we named the ontology LOCO-Cite. The LOCO and ALOCoM ontologies must be related to each other through the LOCO in an OWL file which links properties and classes across the boundaries of the individual ontologies to create a larger, unified ontology. Since the current versions of Protégé are not designed to work with multiple ontologies in the same view, it is necessary to make the changes to the OWL XML file manually and create a new project in Protégé from this file (Knublauch et al, 2004). The OWL/XML is shown in Figure 6 and indicates how the *LearningObjectContext* class from the LOCO-Cite ontology is linked with the related concepts from both the LOCO (the *Learning_object class* from *Figure 4*) and ALOCoM Content Structure (the *LearningObject* class from *Figure 3*) ontologies. First, we define a relation between the LOCO-Cite ontology and the ALOCoM ontology by saying that the *LearningObjectContext* class from the LOCO-Cite is *equivalentTo* the *LearningObject* class from the ALOCoM ontology. Then, we create a relation between the LOCO-Cite ontology and the LOCO through the *hasLearningObject* property of the LOCO-Cite's *Learning_object* class whose range is the *LearningObject* class from the ALOCoM ontology.

```
<rdf:RDF>
        <owl:Ontology rdf:about="">
                <owl:imports rdf:resource="http://www.lornet.org/LOCO"/>
                <owl:imports rdf:resource="http://www.owl-ontologies.com/alocom-core.owl"/>
        </owl:Ontology>
        <owl:Class rdf:about="http://www.lornet.org/LOCO-Cite#LearningObjectContext">
                <owl:equivalentClass rdf:resource="http://www.lornet.org/LOCO#Learning_object"/>
        </owl:Class>
        <owl:ObjectProperty rdf:about="http://www.lornet.org/LOCO-Cite#hasLearningObject">
                <rdfs:domain rdf:resource="http://www.lornet.org/LOCO-Cite#LearningObjectContext"/>
                <rdfs:range rdf:resource="http://www.owl-ontologies.com/alocom-core.owl#LearningObject"/>
        </owl:ObjectProperty>
</rdf:RDF>
```

Figure 6. A snippet of the OWL/XML document linking LOCO, LOCO-Cite, and ALOCoM ontologies

d) An example of a learning design and learning object content

In this subsection, we illustrate how one can use the ontologies described in the previous three subsections to describe all LO components, LDs, and their relations using LOCs. In fact, we show how one can attach LO components to specific parts of LDs. The main idea is to depict the usage of the "What is greatness" LDs originally created by (Dalziel, 2003) for teaching (and introducing) ontologies. We first describe the LO components we want to use in this example. Figure 7 shows a slide from a slide presentation containing several definitions of ontologies as well as an example of an ontology. The content of the slide can be represented using the ALOCoM ontology. In terms of the ALOCoM ontology, the process of converting currently existing LOs represented in their original formats (e.g. text document, slide presentation) into the ALOCoM ontology-compliant format is called disaggregation. Additionally, the process of disaggregation also includes logical and conceptual organization of LO components by recognizing different content object types defined in the ALOCoM ontology.

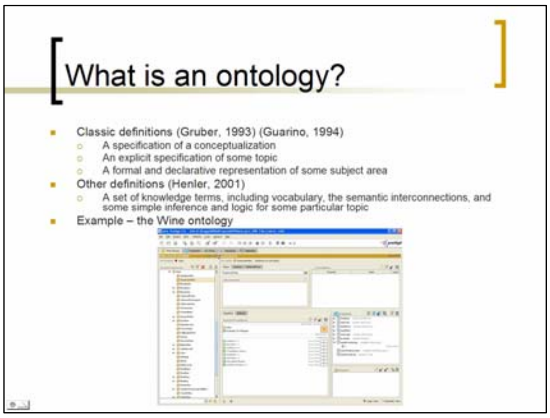

Figure 7. An example of a learning object whose ALOCoM ontology description is shown in Figure 8

Although it was also possible to disaggregate the slide presentation using the ALOCoM toolkit (Verbert et al., 2005), we manually disaggregated the slide for the sake of better readability of the example. Using Protégé, we create content fragments and content objects corresponding to each element in the slide presentation. We then group these pieces into larger content objects using the *hasPart* relation.

Next we anticipate the structure of the LOs we need for construction of our LD. Since we need one LO to serve as an introduction and another LO to serve as an example, we decide to create two ALOCoM LOs, one to hold the introduction content objects and the other to hold the example content objects. Figure 8 shows a representation of the resulting relationships of class instances.

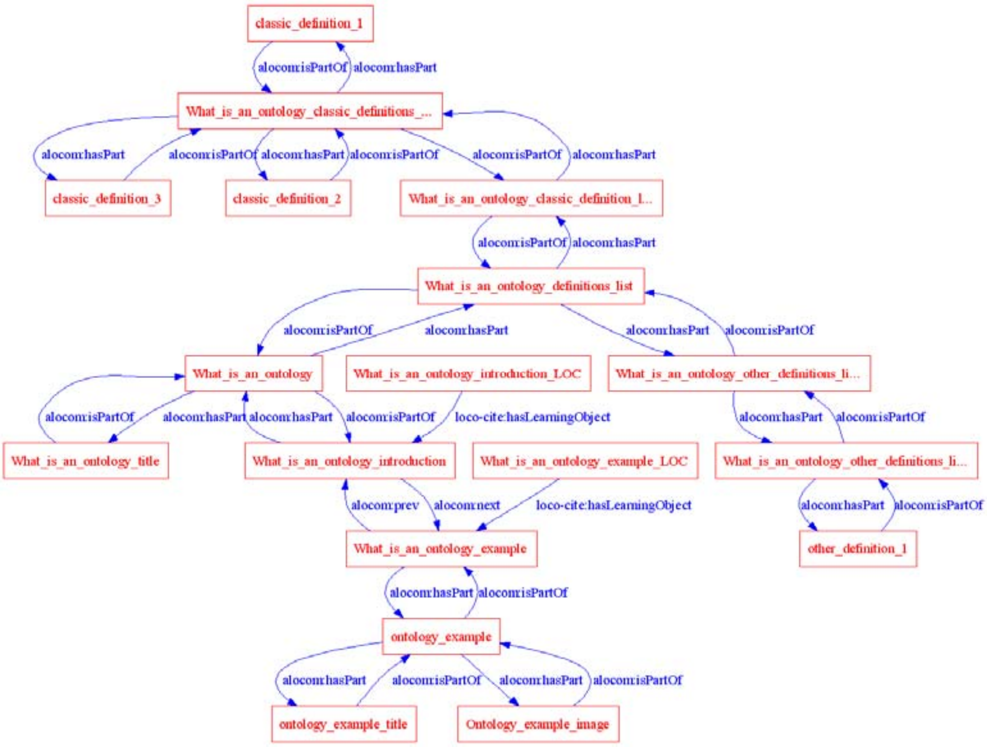

Figure 8. The ALOCoM-based ontology graph of the slide shown in Figure 7

The alocom:LearningObject class instances are named What_is_an_ontology_introduction and What_is_an_ontology_example. Each are associated with alocom:ContentObject or alocom:ContentFragment class instances by the alocom:hasPart and alocom:isPartOf relationships. The LOCs named What_is_an_ontology_introduction_LOC and What_is_an_ontology_example_LOC are instances of the loco-cite:LearningObjectContext class and are used to associate the alocom:LearningObject classes with corresponding loco:LearningObject classes.

We used an existing case study for expressing the "What is greatness" example in IMS-LD (Gorissen, 2004). This learning design provides a set of activities for learners to openly discuss a topic they have just been introduced to, under the supervision of a tutor. We created the learning design in Protégé using the LOCO ontology, and linked the IMS-LD environments to the ALOCoM learning objects by using the loco:hasLearning_object property of the loco:Environment class to associate the environment with the LOC; in this case, the What_is_an_ontology_example_LOC and the What_is_an_ontology_introduction_LOC described in *Figure 8*. The resulting class relationships are shown in Figure 9.

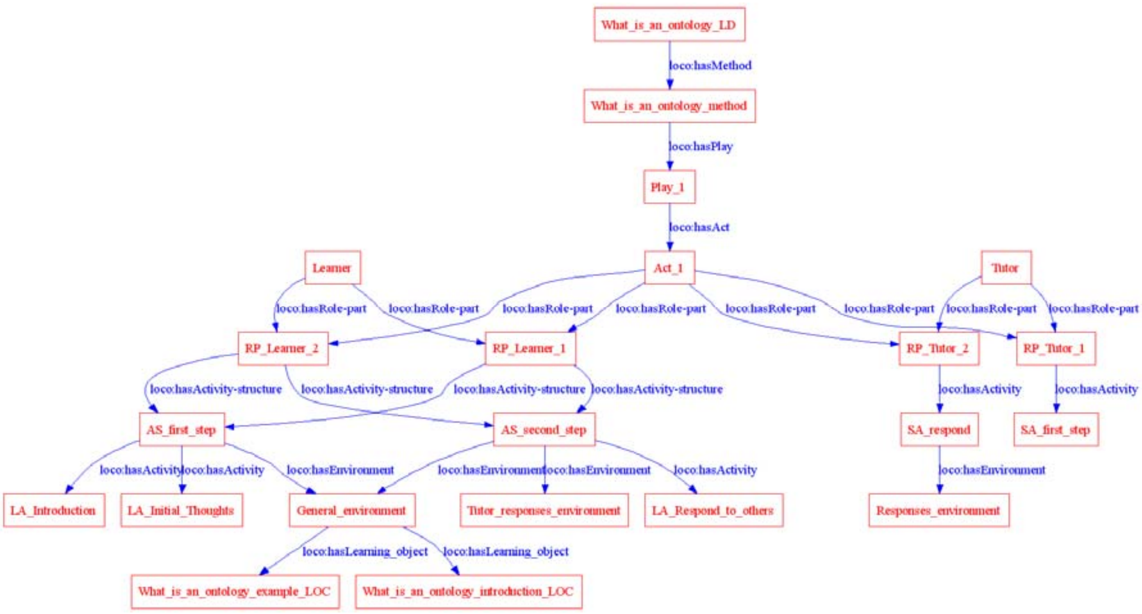

Figure 9. The graph of the LOCO ontology instances representing the "What is greatness?" learning design

Searching for parts of learning designs, searching for learning designs based on the specific content types (e.g. definition) of a specific subject domain, and personalization of the LO content according to learners' profiles within a specific learning design are only a few of the services that we can support by the ontology-based, explicit description of learning designs and LOs as shown in the previous example. In order to clarify one of these ontology-enabled services, we describe competency-based search services in the next section.

Use Cases

LOCO provides an immediate practical benefit in equipping LD with an ontological framework that can be used for the development of Semantic Services. In future, we hope to develop tools (see *Figure 10*) that will leverage the capabilities of ontologies to make it easy to locate and reuse good learning designs, including ones from different subject domain areas. The eventual goals of these tools are to:

- extend some of the present Learning Design Editors (e.g. Reload, LAMS) with the features for exporting/importing LOCO ontology compliant learning designs;
- extend some of the present Learning Design Editors (e.g. Reload, LAMS) with the features for searching LO repositories based on the content ontologies (e.g. ALOCoM) as well as for connecting learning designs to LO content components using LOC defined in LOCO-Cite;
- create LOCO-based repositories of learning designs accessible by present Learning Design Editors.

To illustrate our vision for these tools, we have outlined two use cases that involve searching for learning designs and learning objects based on competencies or quality LOs and LDs for a specific context. The reason for further discussion about competencies is because they have been recently recognized as playing an important role in the selection of learning objects in external or internal repositories and the composition and delivery of the appropriate learning activities (Sicilia, 2005). Having explicitly described competencies using ontologies, one can provide automatic or semi-automatic services for handling competencies in e-learning frameworks. In this paper we distinguish between specific competencies (such as being able to list several definitions of an ontology), and general competencies, which are not tied to a domain and tend to refer to general aptitudes such as group work skills and critical thinking.

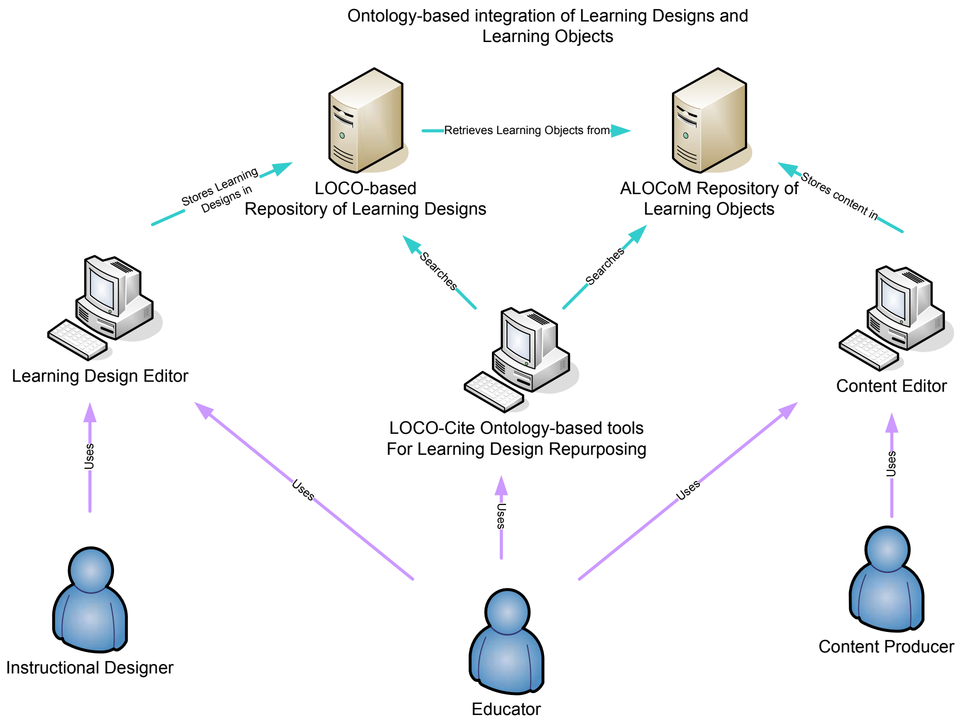

Figure 10. LOCO-based integration of learning designs and learning objects

Here are the two use cases based on the ontology-based conceptual framework for connecting learning designs and learning objects:

Finding a teaching method based on competencies

In this scenario, a teacher will have a list of specific domain competencies and would like to search for the most suitable teaching method in previous practice (if any exist) for these specific domain competencies. Basically, we store the information about the competencies in LOCs that relate LOs from LO repositories (e.g. ALOCoM based) and the learning designs from learning design repositories (e.g. LOCO-based). The rationale for storing the information about the competencies with LOCs rather then with LOs is that the same LO can be used for learning different competencies. By storing the information about the competency with the LOC, we increase the LOs' level of reusability. Using such described LOs, LOCs, and learning designs, the search engine we plan to develop will: take the competencies as the input; look for all LOCs containing these competencies; and return learning designs referred to in the set of found LOCs.

In the case the teacher searches for a learning design that builds on general competencies such as teamwork skills, the above approach for storing competencies with LOCs is applicable as well. Because these skills are not tied to a particular subject domain, the scope of potential learning designs is increased to include learning designs from many different subject areas and levels. The teacher will be able to see learning designs that have worked well building teamwork skills and will substitute learning objects to make the learning design relevant to the specific domain. This would facilitate the reuse of good learning designs across organizational boundaries.

Searching for and selecting quality LOs or learning designs that are most appropriate for a given instructional situation

In this scenario, a teacher performs a search for LOs or LDs as described in scenario 1, but a large number of results are returned. The teacher is given the option to view the results in order of quality ratings, according to

LO and LD reviews associated with the given LOC. Since we have ontology-based descriptions of learning designs and LOs, we can employ ontology-based algorithms for ranking search results by using different weight factors for different ontology relationships (Stojanović et al., 2003). In this case we use the ontology for defining competencies by applying a similar ranking approach for search results. Finally, we can employ different review methods of learning designs like we have with learning objects, such as the eLera system (Li et al., 2004). In that way teachers' quality evaluations can be taken into consideration when ranking learning designs. If we store this information with learning designs, we will decrease their level of reusability. However, by storing them with LOCs, we can employ this information for searching relevant learning designs and still have learning designs in their initial (and hopefully reusable) form.

Conclusions

Having developed an ontology-based framework for connecting learning designs and learning objects consisting of three ontologies (i.e. LOCO, LOCO-Cite, and ALOCoM), we defined a basis for further development of (semi-)automatic services that will be able to reason on top of such an explicit infrastructure. Before we defined that framework, we developed a conceptual model that introduced one additional layer between learning designs and learning objects called learning object contexts. The rationale for having learning object contexts is to relate learning objects and learning designs in a way that increases the level of reusability of both learning objects (e.g. storing the information about learning object competencies with its learning object context, and thus allowing for reusing the same learning object for learning other competencies) and learning designs (e.g. storing the information about quality of a learning design with its learning object contexts). Analyzing the usability of the ontology-based framework, we identified some potential Semantic Services such as:

- Employing the ontology descriptions of learning designs and learning objects to search and reuse them either as a whole or as disaggregated components;
- Finding the most suitable teaching method stored in learning design repositories based on specific competencies;
- Personalizing learning objects according to learners' profiles within a specific learning design by employing an ontology-based description of learning object content;
- Ranking learning designs returned by searches using: different weight factors of ontology relationships defined in the proposed ontologies; users' reviews of both learning designs and learning objects; and ontology-defined competencies.

In the future, we plan to develop tools to extend some of the present learning design editors (e.g. Reload) with support for creating LOCO-based learning designs, with the eventual goal to further evaluate the proposed framework. The proposed LOCO and LOCO-Cite ontologies will serve as the basis for the development of a LOCO-based repository of learning designs and aforementioned ontology-based Semantic Services. The LOCO-Cite ontology will enable, as the result of semantic annotation, the collection of large amounts of data about how learning designs and learning objects are used in practice. From the perspective of learning object content, we plan to set up a learning object repository based on the ALOCoM ontology that will contain learning objects that will be disaggregated using the ALOCoM toolkit (Verbert et al., 2005).

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A Learning Design Ontology based on the IMS Specification

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ABSTRACT

In this paper, we present an ontology to represent the semantics of the IMS Learning Design (IMS LD) specification, a meta-language used to describe the main elements of the learning design process. The motivation of this work relies on the expressiveness limitations found on the current XML-Schema implementation of the IMS LD conceptual model. To solve these limitations, we have developed an ontology using Protégé at the knowledge level. In addition, we provide its implementation in OWL, the standard language of the Semantic Web, and the set of associated axioms in first-order logic. The OWL file is available at *http://www.eume.net/ontology/imsld_a.owl*.

Keywords

IMS Learning Design, Ontologies, Semantic description, Formal axioms

Introduction

In the last years, the popularity of the Internet has opened the door to new ways of learning and numerous educational tools and applications. In this context, the need to manage reusable resources has driven the development of several metadata specifications in order to represent learning content, educational resources and learning design methodologies. This paper focuses on the representational issues of the *learning design*, which describes the method that enables learners to achieve learning objectives after carrying out a set of activities using the resources of an environment.

The specifications for the learning design, known as Educational Modelling Languages (EML), are models of semantic information and aggregation that describe, from a pedagogic point of view, the content as well as the educational activities. These elements are organized into units of study with the aim of allowing their reuse and interoperability (Rawlings et al., 2002). Moreover, EMLs facilitate the description of pedagogic aspects that are related with LOs in educational processes (Koper, 2001). The principal EML specifications are as follows:

- *CDF* (http://www.ariadne-eu.org). It uses the ARIADNE Course Description Format (A-CDF) for the description of courses (Verbert & Duval, 2004). A course in A-CDF consists of XML documents along with a course generator LMS. It places special emphasis on the content and its aggregation, but it is expressive enough to describe the learning process in accordance with a pedagogic model. The didactic material that can be managed through CDF is restricted to text format. It uses a combination of tools developed by the ARIADNE consortium (curriculum editors, LMS, KPS) and establishes the concept of *Course* as a unit of study.
- *LMML* (http://www.lmml.de). An acronym of Learning Material Mark-up Language. It is based on a meta-model in order to be used in different application domains. LMML relies on XML for the description of e-learning material (Slavin et al., 1995), and comprises various learning material modules, each one containing other sub-modules. Focused on a conceptual, modular and hierarchical structure of e-learning content, LMML can be adapted to different learning situations and students. It uses the concept of *Course* as a unit of study.
- *PALO* (http://sensei.lsi.uned.es). It is a modelling language that has been developed by the UNED (Universidad Nacional de Enseñanza a Distancia, Spain) (Rodríguez-Artacho et al., 1999). PALO describes courses organized into modules that contain learning activities, content, and an associated teaching plan. The language provides templates to define types of Learning Scenarios with their associated pedagogic properties. By using the language features, it is possible to establish the sequencing of both modules and learning tasks. According to the course constraints, these attributes also allow to define deadlines and dependencies between modules and tasks. It uses the concept of *Module* as a unit of study.

- *Targeteam* (http://www.targeteam.net). An acronym of TArgeted Reuse and GEneration of TEAching Materials. This language supports the production and management (use and reuse) of learning material (Koch, 2002), including notes and contents such as explanations, motivation, and examples. All these elements can be carefully structured in an interrelated manner. It is focused on the use of an XML-based language, TeachML, and uses the concept of *Issue* as a unit of study. This EML allows the use of material in different learning situations and pedagogic domains (primary, secondary and higher education).
- *TML/Netquest* (http://www.ilrt.bris.ac.uk/netquest). It uses the Tutorial Mark-up Language (TML), an extension of HTML, to produce questions (Brickley, 1996). This language was designed to separate the semantic content of the layout, or on-screen format, from a question. The TML files are in text format, and can be generated from other formats or other questions in a database. This EML does not support the concept of a unit of study.
- *IMS Learning Design (IMS LD)* (http://www.imsglobal.org/learningdesign). This specification, drawn up by the IMS/LDWG work group, is an integration of the EML developed by the OUNL (Open University of Netherlands), with other existing IMS specifications for the exchange and interoperability of e-learning material. The OUNL EML is a meta-vocabulary that is defined based on the diversity of concepts existing in a wide range of pedagogic techniques. The IMS EML incorporates the OUNL EML, and describes the structure and educational processes based on a pedagogic metamodel, using units of learning called *Learning Design* (IMS, 2003a). IMS LD describes a method that is made up of a number of activities carried out by both learner and staff in order to achieve some learning objectives. It allows the combination of various techniques (traditional, collaborative, etc.), and facilitates the description of new ones. From the proposed specifications, the IMS LD has emerged as the *de facto* standard for the representation of any learning design that can be based on a wide range of pedagogical techniques.

The metadata specifications are useful to describe educational resources, and thus to facilitate interoperability and reuse between learning software platforms, as they represent the vocabulary describing the different aspects of the learning process. However, the main drawback is that the meaning of the specification is usually expressed in *natural language*. Although this description is easy to understand for humans, it would be difficult to be automatically processed by software programs. To solve this issue, ontologies (Gómez-Pérez et al., 2004) come handy to describe *formally* and *explicitly* the structure and meaning of the metadata elements; that is, an ontology would semantically describe the metadata concepts. In the educational domain, several ontologies have been proposed: (1) to describe the learning contents of technical documents (Kabel et al., 1999); (2) to model the elements required for the design, analysis, and evaluation of the interaction between learners in computer supported cooperative learning (Inaba et al., 2001); (3) to specify the knowledge needed to define new collaborative learning scenarios (Barros et al., 2002); or (4) to formalize the semantics of learning objects that are based on metadata standards (like LOM) (Brase & Nejdl, 2004). The focus of that research is either on the development of a taxonomy of concepts on the basis of a established theory or specification (1 to 3), or on the formal definition of the metadata using an ontology language (4). However, none of them deal with the formal description of the meaning of the concepts, and they do not address the ontological modelling of any specification for learning design.

In this paper, we present a *learning design ontology* based on the IMS LD specification, the *de facto* meta-language for the learning design. In this ontology, the IMS LD elements are modelled in a *concept taxonomy* in which the relations between the concepts are explicitly represented. Furthermore, a set of *axioms* constraining the semantics of the concepts has been formulated from the restrictions (expressed in natural language) identified in the analysis of the IMD LD specification.

The paper is structured as follows: in the next section, the limitations of the XML-Schema language on representing the IMS LD specification are outlined; then, the concept taxonomy and the ontology axioms are described, and an example illustrates how the ontology could be used; then, a description of how the ontology was implemented and used in an educational environment is presented; and finally, the presented work is discussed and the main contributions are summarized.

The Need for a Learning Design Ontology

The IMS Learning Design specification is a meta-language that describes all the elements of the design of a teaching-learning process (IMS, 2003a). This specification is based on: (1) a well-founded conceptual model that defines the vocabulary and the functional relations between the concepts of the LD; (2) an information model that describes in an informal (natural language) way the semantics of every concept and relation introduced in the conceptual model; and (3) a behavioural model that specifies the constraints imposed to the software system when a given LD is executed in runtime. In other words, the behavioural model defines the semantics of the IMS LD specification during the execution phase.

To facilitate the interoperability between software systems, the IMS LD specification has been formally modelled through the XML-Schema language (Thompson et al., 2004; IMS, 2003b). However, the knowledge model of this language is not expressive enough to describe the semantics (or meaning) associated to the elements of the IMS LD. Thus, the main limitations of the XML-Schema language are (Gil & Ratnakar, 2002):

Hierarchical (is-a) relations between two or more concepts cannot be explicitly defined. Therefore, there are no inheritance mechanisms facilitating the representation of concept taxonomies. For example, in the IMS LD specification, the Learner and Staff elements do not inherit the attributes and relations of the Role element: they are just included as XML sub-elements of the Role element. Figure 1 compares both the OWL and XML-Schema specifications based on the definition of the Learner concept. In OWL, the hierarchical relation between the Learner and Role concepts is explicitly defined through the rdfs:subClassOf, and, therefore, the attributes of Role will be automatically inherited by Learner. In XML-Schema, however, the attributes of Role are directly added to the definition of Learner, but no hierarchical relation is established between them.

- Properties of relations cannot be defined. XML-Schema language does not provide primitives to represent neither mathematical properties (like symmetry or transitivity) nor taxonomic properties (like disjoint and exhaustive partitions) of a relation. For example, the IMS LD specifies that an instance of the Staff cannot be a Learner for any given unit of learning, what means that Staff and Learner are disjoint concepts. Figure 1 shows how this taxonomic property can be explicitly expressed in OWL.
- General and formal constraints (or axioms) between concepts, attributes, and relations cannot be specified. These axioms describe more precisely the semantics of the concepts as they constrain how the instances of the concepts could be created. For instance, the axiom "if an Act is executed in the context of a Play, and both have a given value for the time limit attribute, the value of this attribute for the Play should be greater or equal than the value for the Act" could not be represented in the XML-Schema language. This restriction, however, could be defined in ontology languages like F-Logic (Kiefer et al., 1995) or Ontolingua (Gruber, 1993). In order to describe these kinds of axioms in OWL, a new language, called SWRL (Horrocks et al., 2004), has been submitted to the W3C.

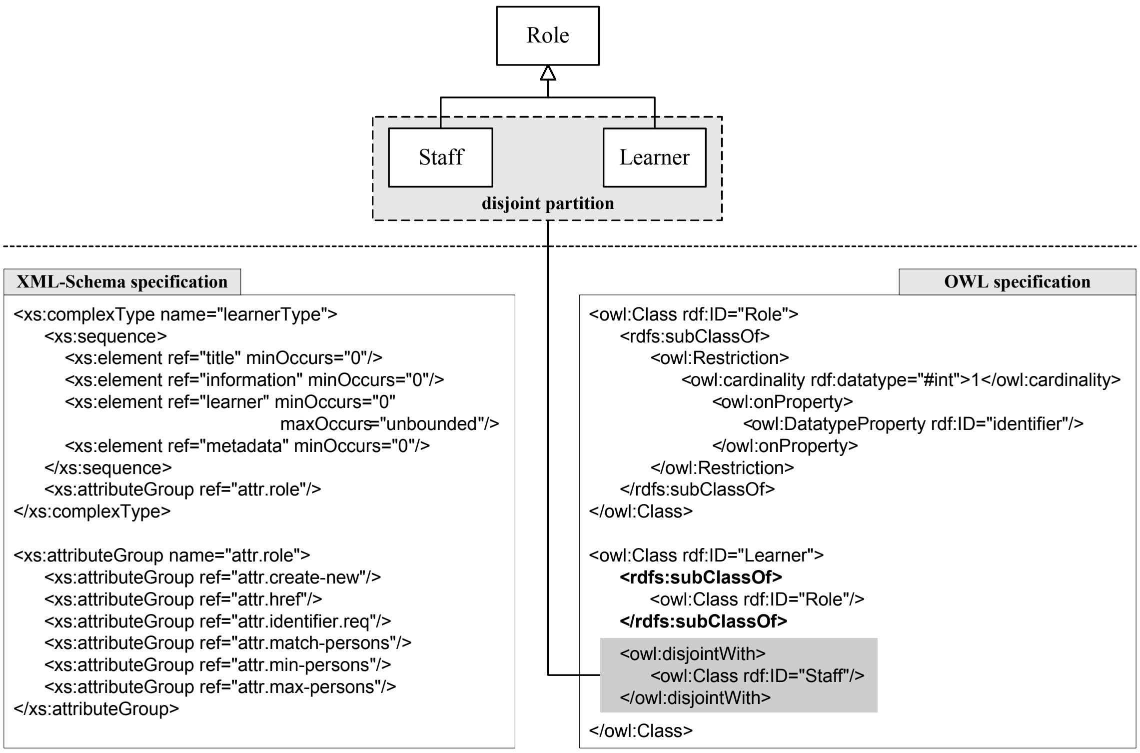


Figure 1. Comparison between the OWL and XML-Schema specifications

Therefore, the IMS LD specification requires a modelling capable of describing *explicitly and formally* the semantics of its elements. To achieve this goal, we have developed an ontology (Gómez-Pérez et al., 2004), which facilitates the semantic description of the conceptual model as well as the definition of formal axioms related to both information and behavioural models. This ontology is based on a knowledge model that includes complex taxonomic relations (like both hierarchical and ad-hoc relations, disjoint and exhaustive partitions, etc.) as well as formal axiom descriptions.

The Learning Design Ontology

To develop the Learning Design ontology we have created a *concept taxonomy*, which describes the elements of the IMS LD conceptual model and the IMS LD information model, and a *set of axioms*, which formally constraint the semantics of the concept taxonomy on the basis of the explanations formulated in natural language in both information and behavioural models.

Description of the Concept Taxonomy

The upper node of the LD ontology is the Unit of Learning concept (Figure 2) that defines a general module of an educational process, like a course or a lesson. Following the IMS LD specification, a unit of learning is modelled as a content package (IMS, 2003a) that integrates the description of both the LD and the set of resources related to it. The Resource concept allows representing various entities, like physical resources (Web pages, files, etc.), and concepts whose attribute description is domain-dependent (learning objectives, prerequisites, etc.). To model the different kinds of resources, we have extended the IMS LD specification with a new hierarchy of concepts (grey boxes in Figure 2). In this way, when a LD concept refers to any of the resource properties, it establishes a relation with the Item concept, which in turn, has a set of subclasses that replicate the hierarchical structure of the resources (following a one-to-one correspondence). These two hierarchies have been introduced to decouple the references to the resources (Item hierarchy) from their modelling (Resource hierarchy). Thus, if two applications use the same LD to model a course, but define resources in a different way (for example, if the learning objectives are specified either as textual description or through their corresponding attributes), the LD does not need to be changed because the links to the resources are indirectly established through the Item hierarchy.

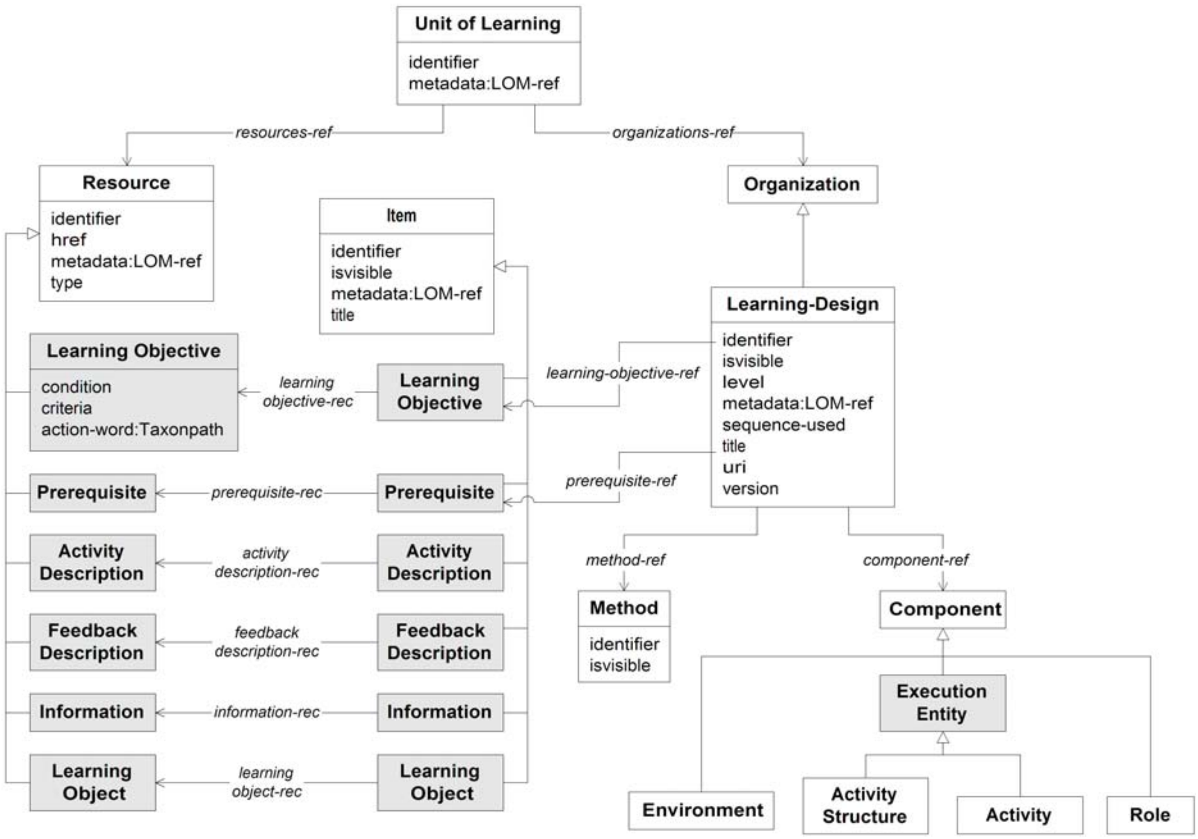


Figure 2. Upper concepts of the Learning Design ontology

Learning Design Description

The Learning Design concept is related to the Learning Objective and Prerequisite concepts, which define the intended outcomes when the unit of learning is carried out, and the previous knowledge needed to participate in it, respectively. Both concepts are subclasses of the Item concept, and therefore they will be mapped onto the Learning objective and Prerequisite concepts of the Resource hierarchy.

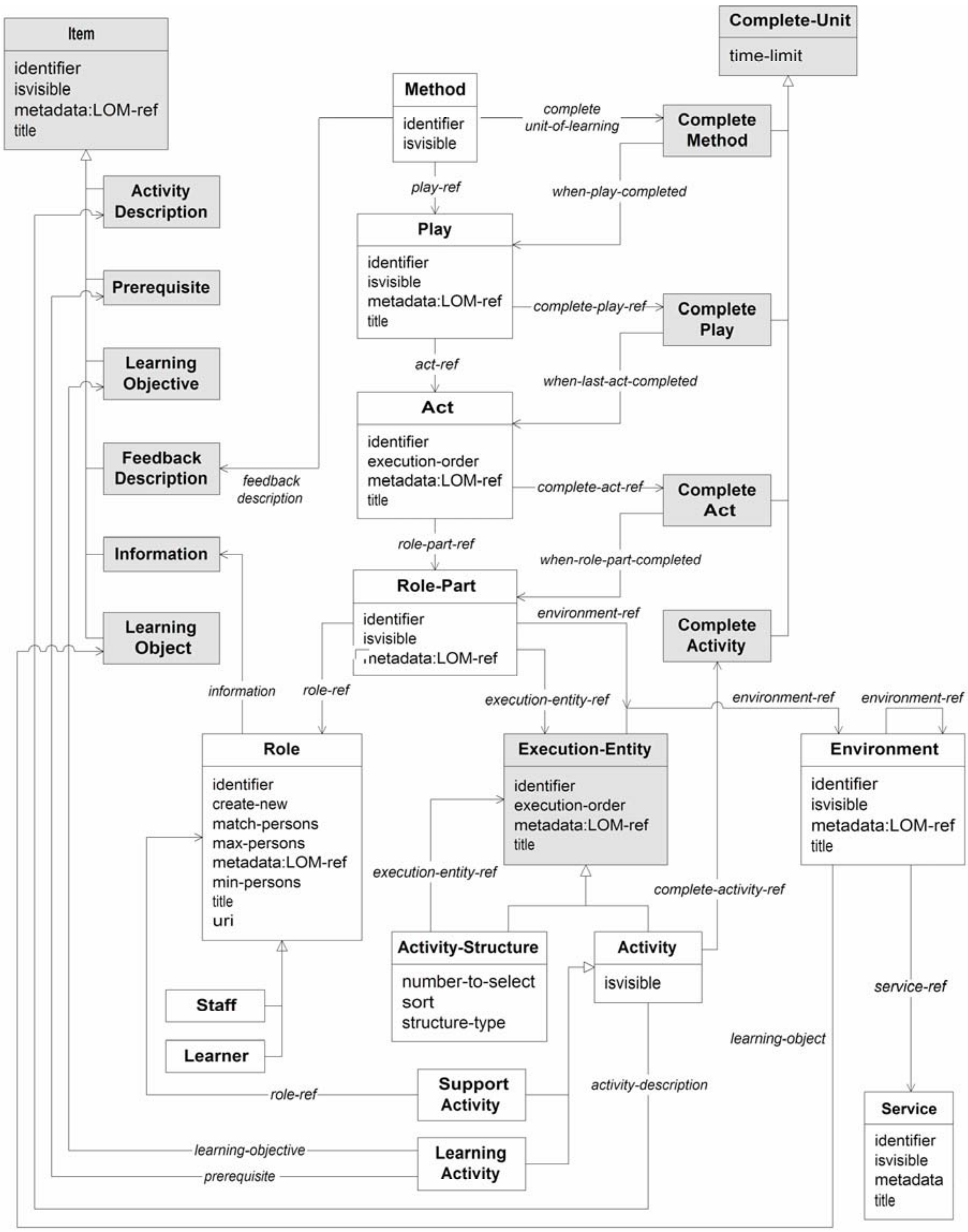


Figure 3. Concept taxonomy that describes the dynamics of a learning design

The Learning Design concept has a number of Components used to describe the learning process: the Execution Entities to be carried out, which can be Activities or Activity Structures (groups of activities that will be executed in sequence); the Roles that participate in the execution of those activities as instances of the Learner and Staff concepts; and the Environments that describe the educational resources to be used in the activities. These concepts constitute an exhaustive and disjoint partition, because an instance of a Component must necessarily be an instance of one of its subclasses.

The Learning Design concept is also related to the Method concept, which describes the dynamics of the learning process (Figure 3): a method is composed of a number of instances of the Play concept that could be interpreted as the runscript for the execution of the unit of learning. All the play instances have to be executed in parallel, and each one consists of Act instances, which could be understood as a stage of a course or module. The Act instances must be executed in sequence (according to the values of the execution order attribute), and they are composed of a number of Role Part instances that will be executed concurrently. A Role Part associates a Role(s) with an Execution Entity to be carried out in the context of the act. Finally, every Execution Entity requires an Environment, which manages Learning Objects as resources. In summary, the execution of an act consists on the simultaneous participation of roles in an activity or group of activities, and once the activities are completed, the associated roles could participate in the execution of any other activity through different role part instances.

The Activity concept has two subclasses: the Learning Activity concept and the Support Activity concept. A Learning Activity models an educational activity that establishes a relation with the Prerequisite and the Learning Objective concepts. The Support Activity, however, is introduced to facilitate the execution of a learning activity, but it does not cover any learning objective. These two classes constitute a disjoint and exhaustive partition, because an instance of the Activity concept should be either a learning or a support activity.

Every concept involved in the dynamics of the learning process (Method, Play, Act, and Activity) establishes a relation with one of the subclasses of the Complete Unit concept, which indicates when an execution is finished. In the IMS LD Level A, this condition can be specified through the time limit attribute, which defines the temporal duration of the execution, or referred to an instance of the entity of which it is composed. For example, an act would be completed when the instance of the Role Part indicated by the relation when-role-part-completed has finished. Furthermore, in both Level B and C of IMS LD, the modelling of these subclasses will be extended to enable the specification of more complex completion conditions.

Description of the Learning Design Ontology Axioms

From a modelling point of view, the formal definition of the semantic constraints of the LD concepts is the main advantages of the learning design ontology when compared with the IMS LD XML-Schema specification. On one hand, the semantics of the concepts are *completely* included in the ontology (not only the taxonomic structure), and, on the other hand, the programmers of LD software systems will not need to understand the descriptions of the IMS LD models in order to translate its meaning in sentences of programming code.

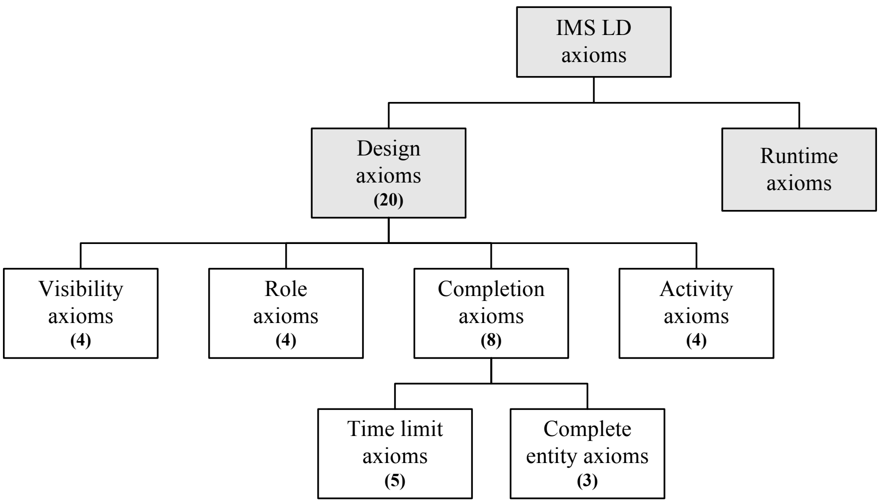


Figure 4. Classification of the axioms identified in the IMS LD ontology

The three models of the IMS LD specification contain a natural language description of the semantics of all the taxonomy concepts, including the *constraints* that should verify their instances when created and managed by a software system. To incorporate these restrictions to the LD ontology we have applied the following procedure: first, the description of the constraints is identified in the text of IMS LD; then, if necessary, this description is reformulated considering the elements of the LD concept taxonomy (concepts, relations, and attributes); and, finally, the restrictions are represented in a declarative, formal, and language-independent way as *axioms* declared in first order logic. Following this procedure, we have identified and formalized a number of axioms that can be classified depending on the phase where the axioms are applied. Thus, two general kinds of axioms are distinguished (Figure 4): design axioms and runtime axioms.

On one hand, *runtime axioms* are associated with the management and monitoring of the execution of the learning design created during the design phase. For example, one of the axioms of this category should guarantee that the plays that compose a method will be executed in parallel. However, to specify many of these axioms it is necessary to *extend* the LD ontology for including a runtime model (not defined in the IMS LD specification) that would represent the different states of execution of the learning design. Most of these axioms have been extracted from the behavioural model.

On the other hand, *design axioms* determine how the instances of the taxonomy concepts will be created when a given learning design has been specified. For example, the first axiom of Table 2 will not allow the creation of a method with a value for the time limit attribute less than the time limit of any of its plays. This kind of axioms guarantee the consistence of all the components of the design created for modelling a unit of learning. Currently, we have extracted and formally defined 20 axioms, most of them from the IMS LD concept and information models. In this paper, we will focus on the description of this kind of axiom.

Design Axiom Description

The axioms have been specified in first order logic as sentences made up of: an antecedent, which contains the conditions to be verified, and a consequent, which describes the constraints to be applied to the concepts, attributes or relations of the ontology (these ontology elements are the universe of discourse). According to this, the axioms could be classified on the basis of the ontology elements whose values or relations are affected by the axiom's consequent part. The following types have been identified (Figure 4): *completion* axioms, *role* axioms, *visibility* axioms, and *activity-related* axioms.

The completion axioms are obtained from the restrictions related to the ending conditions of the elements involved in the runscript (Method, Play, Act and Role-Part). Particularly, these axioms specify both the values of the attributes and relation range associated to the sub-lasses of the Complete Unit concept. Considering this, two kinds of completion axioms could be distinguished (Figure 4): time limit axioms, and entity completion axioms.

The entity completion axioms (Table 1) will restrict the instances of the concepts associated to the range of the relations when-last-act-completed, when-play-completed, and when-role-part-completed, which indicate what are the runscript elements, REI, whose execution marks the ending of a given runscript element, REG. Taking this into account, this kind of axioms establishes that REI must be necessarily a subset of the runscript elements executed in the context of REG.

Table 1. Formal definition of the entity completion axioms

1	IMS LD Specification	*Page 42 (item 0.4.1)*: "This element states that an act is completed when the referenced role-part(s) is (are) completed. More than one role-part can be selected, meaning that all the referenced role-parts must be completed before the act is completed."
	Explanation	The `Role Part(s)` referred as the value of the attribute `when-role-part-completed` of an `Act` must be a subset of the `Role Part(s)` associated to the `Act`.
	Formal Description	$\forall$ a, ca, rp $\mid$ a $\in$ Act $\wedge$ ca $\in$ Complete-Act $\wedge$ complete-act-ref(ca, a) $\wedge$ rp $\in$ Role-Part $\wedge$ when-role-part-completed(rp, ca) $\rightarrow$ role-part-ref(rp, a)
2	IMS LD Specification	*Page 40 (item 0.5.1)*: "This element states that a play is completed when the last act is completed."
	Explanation	The `Act` referred as the value of the attribute `when-last-act-completed` of a `Play` must be one of the `Acts` associated to the `Play`.
	Formal Description	$\forall$ p, cp, a $\mid$ p $\in$ Play $\wedge$ cp $\in$ Complete-Play $\wedge$ complete-play-ref(cp, p) $\wedge$ a $\in$ Act $\wedge$ when-last-act-completed(a, cp) $\rightarrow$ act-ref(a, p)

3	IMS LD Specification	*Page 38 (item 0.4.1)*: "This element states that an unit-of-learning is completed when the referenced play(s) is (are) completed. More than one play can be selected, meaning that all the referenced plays must be completed before the unit-of-learning is completed."
	Explanation	The `Play(s)` referred as the valued of the attribute `when-role-part-completed` of a `Method` must be a subset of the `Plays` associated to the `Method`.
	Formal Description	$\forall$ m, p, cm $\mid$ m $\in$ Method $\wedge$ p $\in$ Play $\wedge$ cm $\in$ Complete-Method $\wedge$ complete-method-ref(cm, m) $\wedge$ when-play-completed(p, cm) $\rightarrow$ play-ref(p, m)

The time limit axioms (Table 2) constrain the possible values of the attribute time-limit that indicates the time interval in which a runscript element is executed. Following the IMS LD specification, for any runscript element the origin of this interval will be the time instant associated to the beginning of the unit of learning. Taking this into account, this kind of axioms establishes that: if the time-limit attribute of the Complete Unit related with a runscript element REI has assigned a value, it must be necessarily greater than the values of the attribute of the Complete Units related to the runscript elements executed in the context of REI (axioms 4 to 6); and the values of the time-limit attribute for the Complete Unit concept must be consistent with the values of the execution-order and structure-type attributes associated with the Acts and Activity Structures concepts respectively (axioms 7 and 8). These axioms guarantee the correct design of the runscript elements whose execution is in sequence.

Table 2. Formal definition of the time limit axioms

4	IMS LD Specification	*Page 38 (item 0)*: "The method contains a sequence of elements for the definition of the dynamics of the learning process. It consists of one or more play(s)." *Page 38 (item 0.2.2)*: "The time limit specifies that it is completed when a certain amount of time has passed, relative to the start of the run of the current unit of learning. The time is always counted relative to the time when the run of the unit-of-learning has started. Authors have to take care that the time limits of role-parts, acts and plays are logical."
	Explanation	The value of the attribute `time limit` associated to a `Method` (through its `Complete Method`) must be greater than the value of the `time-limit` associated to any `Play` (through its `Complete Play`) that is executed in the context of the `Method`. That is, the `Plays` cannot finish after the `Method`.
	Formal Description	$\forall$ m, p, cm, cp $\mid$ m $\in$ Method $\wedge$ p $\in$ Play $\wedge$ cm $\in$ Complete-Method $\wedge$ cp $\in$ Complete-Play $\wedge$ play-ref(p, m) $\wedge$ complete-unit-of-learning-ref(cm, m) $\wedge$ complete-play-ref(cp, p) $\rightarrow$ time-limit(cm) $\geq$ time-limit(cp)
5	IMS LD Specification	*Page 39 (item 0)*: "A Play consists of a series of acts and an act consists of a series of role-parts. When there is more than one play, these are interpreted concurrently and independent of each other." *Page 40 (item 0.5.2):* As the item 0.2.2 in page 38.
	Explanation	The value of the attribute `time-limit` associated to a `Play` (through its `Complete Play`) must be greater or equal than the value of the `time limit` associated to any `Act` (through its `Complete Act`) that is executed in the context of the `Play`. That is, an `Act` cannot finish after the `Play`.
	Formal Description	$\forall$ p, cp, a, ca $\mid$ p $\in$ Play $\wedge$ cp $\in$ Complete-Play $\wedge$ complete-play-ref(cp, p) $\wedge$ a $\in$ Act $\wedge$ ca $\in$ Complete-Act $\wedge$ complete-act-ref(ca, a) $\wedge$ act-ref(a, p) $\rightarrow$ time-limit(cp) $\geq$ time-limit(ca)
6	IMS LD Specification	*Page 42 (item 0.4.2)*: As the item 0.2.2 in page 38. *Page 41 (item 0.3)*: "A play consists of a series of acts and an act consists of a series of role-parts. A role-part relates exactly one role to exactly one type of activity (including the performance of another unit-of-learning and activity-structures). Role-parts within one act, are performed concurrently."
	Explanation	The value of the attribute `time limit` associated to an `Act` (through its `Complete Act`) must be greater than the value of the `time-limit` associated to any `Activity` related to a `Role-Part` that is executed in the context of the `Act`. That is, the `Role-Parts` cannot finish after the `Act`.
	Formal Description	$\forall$ a, ca, actv, as, rp $\mid$ a $\in$ Act $\wedge$ ca $\in$ Complete-Act $\wedge$ complete-act-ref(ca, a) $\wedge$ rp $\in$ Role-Part $\wedge$ role-part-ref(a, rp) $\wedge$ actv $\in$ Activity $\wedge$ cactv $\in$ Complete-Activity $\wedge$ complete-activity-ref(cactv, actv) $\wedge$ as $\in$ Activity-Structure $\wedge$ (execution-entity-ref(actv, rp) $\vee$ (execution-entity-ref(as, rp) $\wedge$ execution-entity-ref(actv, as))) $\rightarrow$ time-limit(ca) $\geq$ time-limit(cactv)
7	IMS LD Specification	*Page 41 (item 0)*: "When there is more than one act in a play, these are presented in sequence from first act to last act. Only one act in a play is the active act at any moment in time, starting with the first. When the first act is completed, the second act is made the active act. When the second act is completed, the third act is made active, etc."
	Explanation	If the value of the attribute `execution-order` of an `Act` is greater than the value of the `execution-order` for other `Act`, and both `Acts` are executed in the context of a same `Play`, the value of the attribute `time-limit` associated to the first `Act` (through its `Complete Act`) is greater than the value of the attribute for the second `Act`.

	Formal Description	∀ p, a, b, ca, cb ∣ p ∈ Play ∧ a, b ∈ Act ∧ act-ref(a, p) ∧ act-ref(b, p) ∧ ca, cb ∈ Complete-Act ∧ complete-act-ref(ca, a) ∧ complete-act-ref(cb, b) ∧ (execution-order(a) ≥ execution-order(b)) → time-limit(ca) ≥ time-limit(cb)
8	IMS LD Specification	*Page 31 (item 0)*: "An activity structure groups activities in sequences or selections."
	Explanation	If the value of the attribute `structure-type` of an `Activity Structure` is "sequence", and there are two activities executed in the context of the same `Activity Structure` with consecutive values for the attribute `execution order`, the value of the attribute `time limit` associated to these `Activities` must be consistent with the values of the `execution order` attribute.
	Formal Description	∀ as, a, ca, b, cb ∣ as ∈ Activity-Structure ∧ structure-type(as) = "sequence" ∧ a, b ∈ Activity ∧ execution-entity-ref(a, as) ∧ execution-entity-ref(b, as) ∧ complete-activity-ref(ca, a) ∧ complete-activity-ref(cb, b) ∧ (execution-order(a) = execution-order(b) + 1) → time-limit(ca) ≥ time-limit(cb)

The visibility axioms (Table 3) restrict the value of the attribute isvisible associated to the learning design elements, establishing the conditions under which they can be accessible to the user through a graphical interface. Based on that, these axioms determine the value of the attribute isvisible for the following elements: the Activities executed in the context of an Activity Structure (axiom 9); the Environments used in the execution of either Activity Structures or Activities (axioms 10 and 11); and the Prerequisites and Learning Objectives related to the learning design (axiom 12). This kind of axiom must also be applied in the runtime phase as the visibility constraints have to be guaranteed during the execution of the unit of learning.

Table 3. Formal definition of the visibility axioms

9	IMS LD Specification	*Page 83 (item 17)*: "Environments are connected to activities, activity-structures or roles (in a role-part). When an activity-description is visible, always the connected environment (including the content structure of the environment) must be made visible. It must be possible to access and see the activity-description and the content of one of the objects or services within the environment at the same time."
	Explanation	When the value of the `isvisible` attribute of an `Activity Description` is "true", the value of that attribute for the `Environments` connected to the `Activity` associated to the `Activity Description` must be also true.
	Formal Description	∀ a, ad, e, lo, s ∣ a ∈ Activity ∧ ad ∈ Activity-Description ∧ activity-description-ref(ad, a) ∧ e ∈ Environment ∧ lo ∈ Learning-Object ∧ s ∈ Service ∧ learning-object-ref(lo, e) ∧ service-ref(s, e) environment-ref(e, a) ∧ isvisible(ad) = "true" → isvisible(lo) = "true" ∧ isvisible(s) = "true"
10	IMS LD Specification	*Page 94 (item 6)*: "When a role is tagged to allow for the creation of new roles, the visibility rules and the users for the parent are applied to the children."
	Explanation	If the value of the attribute `create-new` of the `Role` is "allow", the values of the attribute `isvisible` of the activities related to the `Role` are the same as the values of the attribute `isvisible` of the activities related to the (sub) `Roles` of that `Role`.
	Formal Description	∀ r, r1, rp, rp1, a, a1, as ∣ r ∈ Role ∧ r1 ⊂ r ∧ create-new(r) = "allow" ∧ rp, rp1 ∈ Role-Part ∧ role-ref(r, rp) ∧ role-ref(r1, rp1) ∧ a, a1 ∈ Activity ∧ as ∈ Activity-Structure ∧ (execution-entity-ref(a, rp) ∨ (execution-entity-ref(as, rp) ∧ execution-entity-ref(a, as))) ∧ (execution-entity-ref(a1, rp1) ∨ (execution-entity-ref(as, rp1) ∧ execution-entity-ref(a1, as)) ∧ a = a1 → isvisible(a) = isvisible(a1)
11	IMS LD Specification	*Page 16*: "When an activity-structure references one or more environments, then these will overrule the environments specified within the referenced activities."
	Explanation	The value of the attribute `isvisible` for the `Learning Objects` and `Services` of an `Environment` associated to an `Activity` must be "false" when there are `Learning Objects` and `Services` of an `Environment` associated to an `Activity Structure` in which such `Activity` is executed.
	Formal Description	∀ as, a, e, e1, e2 ∣ as ∈ Activity-Structure ∧ a ∈ Activity ∧ execution-entity-ref (a, as) ∧ e ∈ Environment ∧ e1, e2 ∈ e ∧ environment-ref(e1, as) ∧ environment-ref(e2, a) ∧ (∃ lo1, lo2 ∣ lo1, lo2 ∈ Learning-Object ∧ learning-object-ref(lo1, e1) ∧ learning-object-ref(lo2, e2)) → isvisible(lo2) = "false" ∀ as, a, e, e1, e2 ∣ as ∈ Activity-Structure ∧ a ∈ Activity ∧ execution-entity-ref (a, as) ∧ e ∈ Environment ∧ e1, e2 ∈ e ∧ environment-ref(e1, as) ∧ environment-ref(e2, a) ∧ (∃ s1, s2 ∣ s1, s2 ∈ Service ∧ service-ref(s1, e1) ∧ service-ref(s2, e2) → isvisible(s2) = "false"
12	IMS LD Specification	*Page 83 (item 12)*: "The learning-design/learning-objectives/item(s) and /prerequisites/items(s) must be accessible for all the roles, at all times in the user-interface."
	Explanation	The value of the attribute `isvisible` of the `Prerequisites` and `Learning Objectives` associated to the `Learning Design` concept must be "true".

	Formal Description	∀ ld, lg, pr │ ld ∈ Learning-Design ∧ lg ∈ Learning-Objective ∧ pr ∈ Prerequisite ∧ prerequisite-ref(pr, ld) ∧ learning-objective-ref(lg, ld) ∧ isvisible(ld) = "true" → isvisible(lg) = "true" ∧ isvisible(pr) = "true"

The role axioms (Table 4) constrain how the instances of the Role concept must be created in the learning design. Thus, depending on the values of the Role attributes (match-persons, min-persons, and create-new), a number of instances of that concept could be created (axioms 14 and 15). Furthermore, there are instances that restrict how the Role instances can be used in the definition of the other learning elements (axiom 16). The role axioms are also applied to the subclasses of Roles that are typically created to specify different categories of teachers or users of the Services managed the Environments associated to the Execution Entities of the learning design.

Table 4. Formal definition of the role axioms

13	IMS LD Specification	*Page 25 (item 0.2.6)*: "Specifies the minimum number of persons bound to the role before starting a run. When the attribute min-persons and max-persons are empty, there are no restrictions. When used, the following rule applies: 0 <= min-persons <= max-persons."
	Explanation	The value of the attribute `max-persons` of a `Role` must be greater than the value of the attribute `min-persons` of that `Role`.
	Formal Description	∀ r│r ∈ Role → max-persons(r) ≥ min-persons(r)
14	IMS LD Specification	*Page 25 (item 0.2.1)*: "This attribute [create-new] indicates whether multiple occurrences of this role may be created during runtime. When the attribute has the value "not-allowed" then there is always one and only one instance of the role."
	Explanation	If the value of the attribute `create-new` of a `Role` is "not allowed", there is a unique instance of that `Role`.
	Formal Description	∀ r │ r ∈ Role ∧ create-new(r) = "not-allowed" → ¬ ∃ r1 │ r1 ∈ r
15	IMS LD Specification	*Page 25 (item 0.2.4)*: "This attribute is used when there are several sub roles (e.g. chair, secretary, member). Persons can be matched exclusively to the sub roles, meaning that a person, who has the role of chair, may not be bound to one of the other roles at the same time."
	Explanation	If a `Role` has (sub) `Roles` and the value of the attribute `match persons` of that `Role` is "exclusively-in-roles", the (sub) `Roles` must be disjoint.
	Formal Description	∀ r, r1, r2, p1, p2 │ r ∈ Role ∧ match-persons(r) = "exclusively-in-roles" ∧ r1, r2 ∈ r ∧ p1, p2 ∈ Person ∧ p1 ∈ r1 ∧ p1 ∈ r1 → p1 ≠ p2
16	IMS LD Specification	*Page 90*: "The same role can be associated with different activities or environments in different role-parts, and the same activity or environment can be associated with different roles in different role-parts. However, the same role may only be referenced once in the same act. If multiple activities or environments need to be associated for the same role an activity-structure or wrapper environment should be used."
	Explanation	For a same `Act`, a given instance of a `Role` can just appear once in the `Role Parts` executed in the context of that `Act`.
	Formal Description	∀ a, r, rp │ a ∈ Act ∧ r ∈ Role ∧ rp ∈ Role-Part ∧ role-part-ref(rp, a) ∧ role- ref(r, rp) → ¬ ∃ rp1 │ rp1 ∈ Role-Part ∧ rp1 ≠ rp ∧ role-part-ref(rp1, a) ∧ role-ref(r, rp1)

Finally, the activity axioms (Table 5) constrain the relations between the Execution Entities and the other components of the learning design. Thus, there are axioms to determine what Roles are involved in the Support Activities (axioms 17 and 18), to restrict the values of the attributes of the Activity Structure concept (axiom 19), and to constrain the relation between the Acts and the Execution Entities of a given design (axiom 20).

Table 5. Formal definition of the activity axioms

17	IMS LD Specification	*Page 29 (item 0)*: "When the optional role-ref element is set, it is expected that the support activity will act for every single user in the specified role(s). That is: the same support activity is repeated for every user in the role(s)."
	Explanation	If a `Support Activity` has assigned a `Role` (that is, the attribute `role-ref` has a value), this activity will be executed by all the instances of the subclasses of such `Role`. On the other hand, it is necessary to define a `Role-Part` for each subclass of the `Role` that is applied to the `Support Activity`.

	Formal Description	∀ a, rp, sa, r, p │ a ∈ Act ∧ rp ∈ Role-Part ∧ role-part-ref(rp, a) ∧ sa ∈ Support-Activity ∧ r ∈ Role ∧ role-ref(r, sa) → ∃ r1, rp1 │ rp1 ∈ Role-Part ∧ role-part-ref(rp1, a) ∧ r1 ∈ r ∧ role-ref(r1, rp1) ∧ execution-entity-ref(sa, rp1) ∀ sa, r, r1 │ sa ∈ Support-Activity ∧ r ∈ Role ∧ role-ref(r, sa) ∧ r1 ∈ r → role-ref(r, rp)
18	IMS LD Specification	Page 29 (item 0): "When the role-ref is not available, the support activity is a single activity (like the learning-activity)."
	Explanation	If a `Support Activity` has not assigned a `Role` (that is, the attribute `role-ref` has not a value), it will be considered as a simple `Activity`, and there would not be applied to every instance of the `Role`.
	Formal Description	∀ rp, sa, r, as │ rp ∈ Role-Part ∧ sa ∈ Support-Activity ∧ as ∈ Activity-Structure ∧ r ∈ Role → ¬ ∃ r1 │ r1 ∈ r ∧ role-ref(r1, rp) ∧ (execution-entity-ref(sa, rp) ∨ (execution-entity-ref(as, rp) ∧ execution-entity(sa, as)))
19	IMS LD Specification	*Page 31 (item 0)*: "When the attribute 'number-to-select' is set, the activity-structure is completed when the number of activities completed equals the number set. The number-to-select must be the same as or smaller than the number of activities (including unit-of-learnings) which are at the immediate child level."
	Explanation	The value of the attribute `number to select` of the `Activity Structure` must be smaller than the number of the `Activities` of that `Activity Structure`. To express this axioms it is necessary to define a variable that is the number of `Activities` of which an `Activity Structure` is composed of.
	Formal Description	∃ na ∈ Integer │na = 0 → ¬ ∃ as, a │as ∈ Activity-Structure ∧ a ∈ Activity ∧ execution-entity-ref(a, as) ∀ as, a│as ∈ Activity-Structure ∧ a ∈ Activity ∧ execution-entity-ref(a, as) → na = na + 1 ∀ as│as ∈ Activity-Structure ∧ number-to-select(as) ≤ na
20	IMS LD Specification	Page 76: "Each role-part associates exactly one role with exactly one type of activity (including the performance of another unit-of-learning and activity-structures), or with one environment (equivalent to an organization in Content Packaging)."
	Explanation	In an `Act` must exist at least an `Role Part` that has assigned an `Activity` or `Activity Structure`. If this axiom is not included in the ontology specification, it could be possible that all the `Role Parts` of an `Act` establish relations with the `Environment`, which is not an `Execution Entity` and, therefore, does not define any ending condition (through the `when-role-part-completed` or `time-limit` attributes).
	Formal Description	∀ act │ act ∈ Act → ∃ rp, as, a │ rp ∈ Role-Part ∧ role-part-ref(rp, act) ∧ as ∈ Activity-Structure ∧ a ∈ Activity ∧ (execution-entity(a, rp) ∨ (execution-entity(as, rp) ∧ execution-entity(a, as)))

Modelling Issues of the Learning Design Ontology

The learning design ontology has been developed for semantically describing every element of the IMS LD specification, solving the drawbacks of its representation in XML-Schema. In this development, new classes (or concepts) were introduced with the aim of improving the modelling of the IMS LD elements, but these classes do not add new learning elements that would extend the IMS LD specification (such as an ontology of educational organizations). In fact, it would be possible to carry out a straightforward translation from the XML-Schema representation of the IMS LD into the learning design ontology, and vice versa. Considering this, these new classes would be translated in the following way: The Execution-Entity, Complete-Unit and Item classes are abstract, which means that they are not instantiated when a learning design is specified. Therefore, these three classes will not be translated, because they are not considered as part of a given learning design, and they were introduced in the LD ontology to improve the structure of the taxonomy by taking advantage of the inheritance and subsumption mechanisms (particularly useful for description logic reasoners).

All the subclasses of the abstract classes are directly related to an XML-Schema element, or groups of elements, that represents an entity of the IMS LD specification: both ontology classes and XML-Schema elements have the same attributes, which means that the translation between them will be straightforward. Nevertheless, in the translation from the ontology classes into XML-Schema, there exist semantic (or knowledge) loss because the ontology classes are more expressive.

To improve the semantic description of the taxonomy concepts of the LD ontology and increase the reasoning capabilities of the ontology, taxonomic (such as disjoint and exhaustive) and mathematical (such as inverse, symmetric and transitive) properties of relations have also been added to the LD ontology. However, these properties cannot be considered extensions of the IMS LD specification, because they do not introduce new elements to the learning design.

Finally, the axioms formulated in the LD ontology are the formal specification of the constraints among the elements of a learning design. In the IMS LD specification these constraints are expressed in natural language, while in the LD ontology they are represented in first order logic. Therefore, the axioms of the ontology are not an extension of the IMS LD specification either: they are the *same* entities represented in a different way.

Modelling Example: Description of the Jigsaw Methodology

Cooperative learning is a technique in which learning is achieved by means of group activities. In this type of learning, the acquisition of knowledge and skills comes about as the result of the interaction among groups, being based on aspects such as individual responsibility, positive interdependence (each individual depends on all the others in order to succeed) and the development of the interpersonal abilities that are necessary in real life situations. With the use of cooperative learning techniques, educational processes may obtain many benefits from the perspective of motivation, cognoscence and social cohesion (Sub et al., 1999). Broadly speaking, cooperation-based teaching/learning processes can be organized according to the following procedures:

1. The didactic objectives are presented to the students.
2. An initial assessment is made.
3. The objectives of each group are defined.
4. The content and evaluation criteria are explained in detail.
5. The groups carry out the activity.
6. The students evaluate each other's work.
7. The professor provides an individual evaluation.
8. Each group is evaluated.

Those groups that failed on achieving the objectives are reorganized.

There are various didactic techniques aimed at establishing co-operational relationships during learning activities: jigsaws, investigation groups, STAD (Student Team-Achievement Divisions) technique, TGT (Teams-Games Tournaments) and peer tutorship. To demonstrate the application of the IMS-LD ontology, the Jigsaw methodology has been chosen (Figure 5). Besides its popularity, this technique is suitable to understand how cooperation-based learning activities are carried out in activities that can easily be broken down into their constituent parts. In short, the Jigsaw follows the general procedure described above, organizing the students into groups of 4 or 5 individuals, and assigning different learning material to each member of the group, so that each student receives a fragment of the information of any given topic that is the matter of the study. Each member prepares the topic with his personal material, joining up with the members of the other groups who have the same topic. After that, he returns to his own group in order to explain and discuss the topic along with the other members.

As it can be seen in Figure 5, the Method representing the Jigsaw approach has a Play made up of a set of Acts, which are executed in sequence. Each Act comprises a set of concurrent Role Parts that relate roles (professor, student, etc.) with activities. The Complete Act concept is used to control the end of an Act, either stating the maximum time for the realization of the Act, or the associated Role Parts that must be completed. For example, the First-Moment Act refers to the activities to be performed during the initial stage of the Jigsaw (corresponding to the general steps 1-4 described above) and is made up of two Role Parts (Ap_Work and In_Att). A relation jsfm-wrpc:when-role-part-completed between the instances jsfm-cp of Complete Act and In_Att of Role Part is used to indicate when this Act is completed. In this Act, the professor carries out the following activities with the groups: objectives presentation, in which he explains the topic of the subject; student assessment, in which an assessment in order to verify the students' prospects and needs is carried out; group creation, in which the activities to be realized and the rules and criteria of the evaluation are explained. These activities are represented by a series of Support or Learning Activities that are grouped into Activity Structures. Each Role Part associates a single Support Activity, Learning Activity or Activity Structure to a certain Role, as it is shown in Figure 6. An activity Structure is completed when the value of the number-to-select attribute is equal to the number of the activities in the set that have been completed. In the example shown in Figure 6, Ap-Wrk-AS will be completed when 6 activities have been completed.

The two `Acts` following the *First-Moment* are the key moments in the Jigsaw technique. The *Jigsaw Part 1* comes when the groups are formed with students with the same study topic. Each topic is a part of the whole subject to be studied, around which the students carry out the activities according to the information that has been supplied by the professor. In the *Jigsaw Part 2* each group comprises students that, collectively, possess all the study material. In this `Act`, each student explains the topic that he has previously studied to the rest of the group. In parallel, the professor monitors and guides the activities carried out by each group.

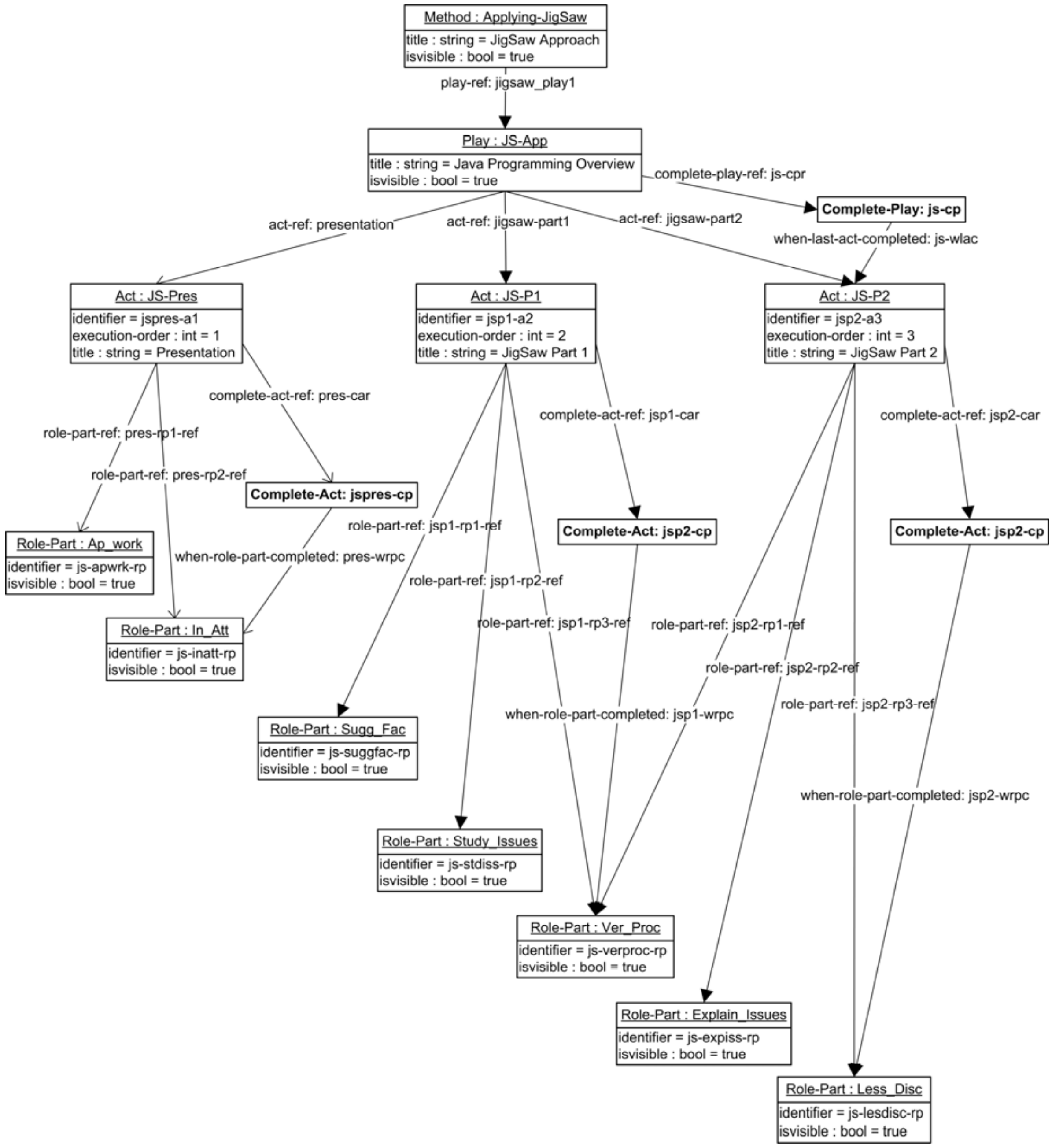


Figure 5. Definition of the Method, Plays and Acts of the Jigsaw example

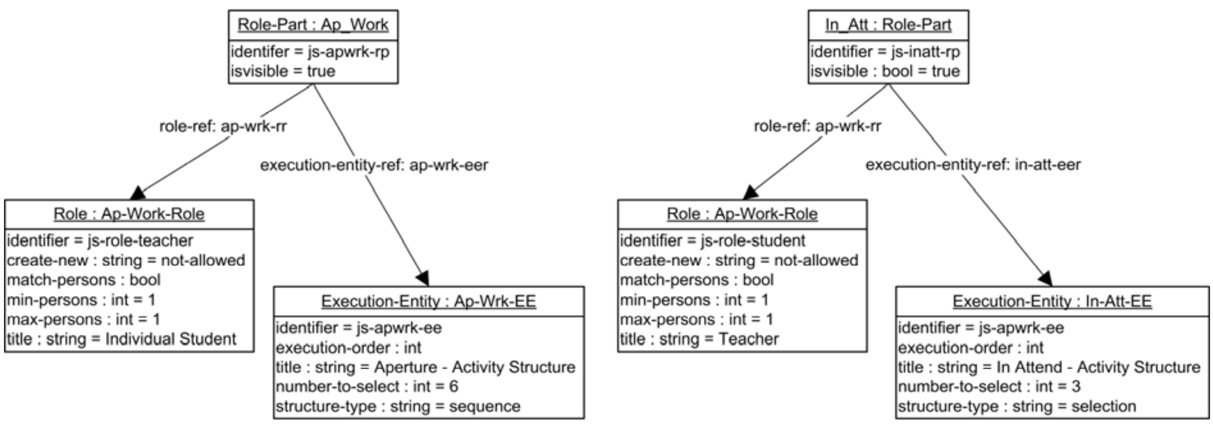


Figure 6. Definition of the Role Parts of the Jigsaw example

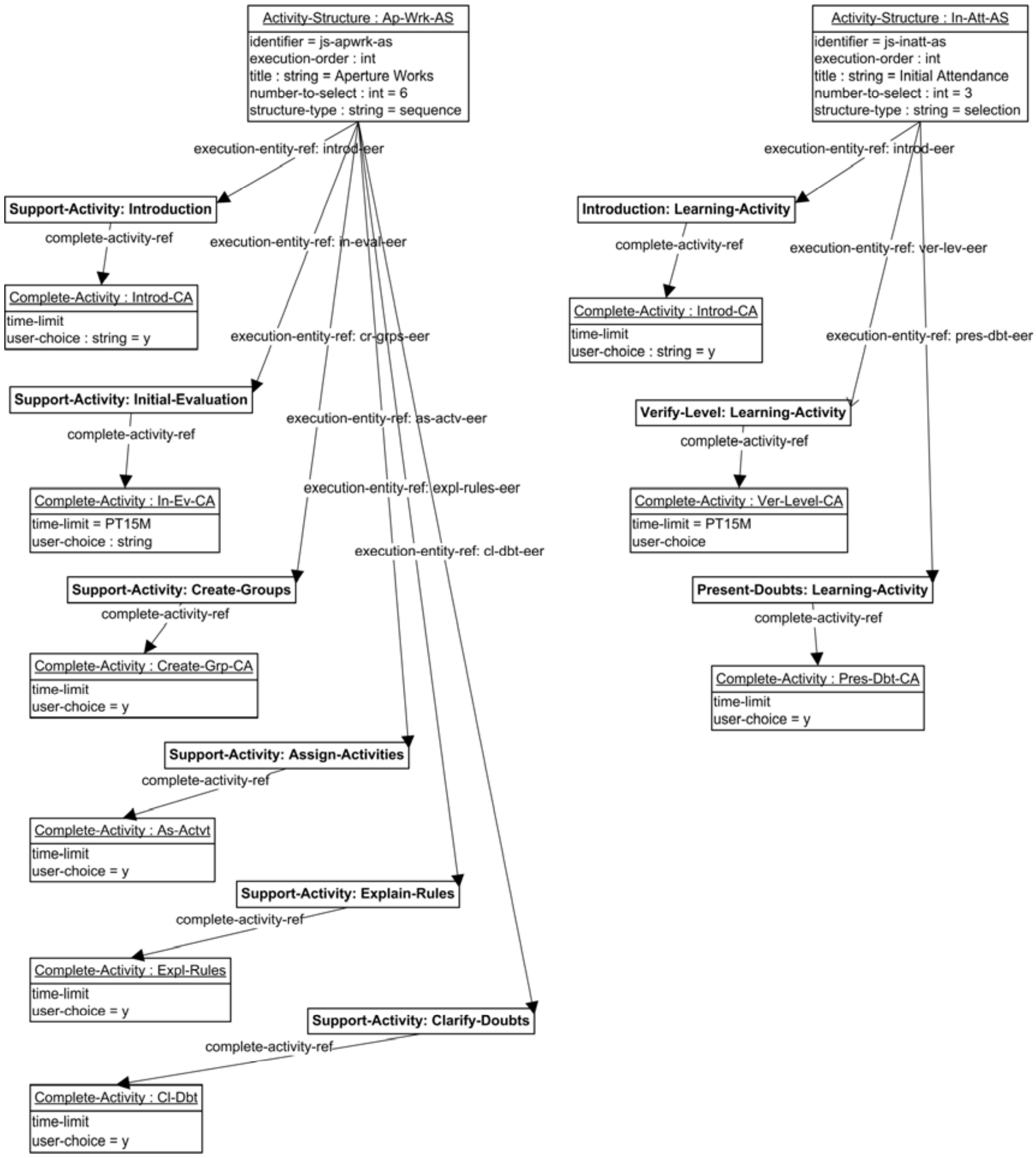


Figure 7. Definition of the Activity Structures of the Jigsaw example

The Acts and Role-Parts shown in Figures 5 and 6 partially represent the dynamics of the educational process. Using Activity-Structures this dynamics can be described in much more detail, according to workflows determining the way in which Support and Learning Activity will be executed in an educational process. Figure 7 shows the order and conditions in which the activities of the professor and the groups are carried out in the First-Moment Act.

The order in which the activities in an Activity Structure are carried out is determined by means of the execution-order and structure-type attributes. The Activity Structure Ap-Wrk-AS, associated with the professor, presents a structure-type attribute with value “sequence”, indicating that the professor executes the Support Activity in a sequence, while the Activity Structure In-Att-AS, related to the groups, shows a “selection” value, indicating that the order of execution depends on a parameter. In this case, the order of the students' activities depends on the professor. Using the Complete Activity concept, activities may be completed by a decision of the role, or at the end of a given time. The support activity Introduction is completed with a decision made by the professor (setting the user-choice attribute), and the Support Activity Initial-Evaluation is completed after the completion of a given time interval (setting the time-limit attribute). The Support Activities Introduction and Explain-Rules determine the beginning of the Learning Activities Introduction and Clarify-Doubts. When an activity is finished, an action to be carried out can be indicated with the Completion Unit and Feedback Description concepts, which are related by the completion-ref relation. For example, with these concepts, a resource can be assigned to present information regarding activity feedback. This may be highly useful when considering the individual reforming of those groups that did not attain the objectives, or when considering future activities.

Associated to the Learning Activities, the Learning Objectives aid the professor, along with the students, to evaluate the learning process. For example, the objective for the Learning Activity, Verify-Level in the First-Moment Act, would be to verify the students' level of knowledge in order to be able to subsequently define the group in a homogeneous manner. In this case, this Learning Activity may consist of a 50-question, multiple-choice questionnaire for which the students have 25 minutes. As a way of homogenizing the groups, the professor would be able to exempt those students with marks of 85% or over from the Jigsaw activities (Figure 8).

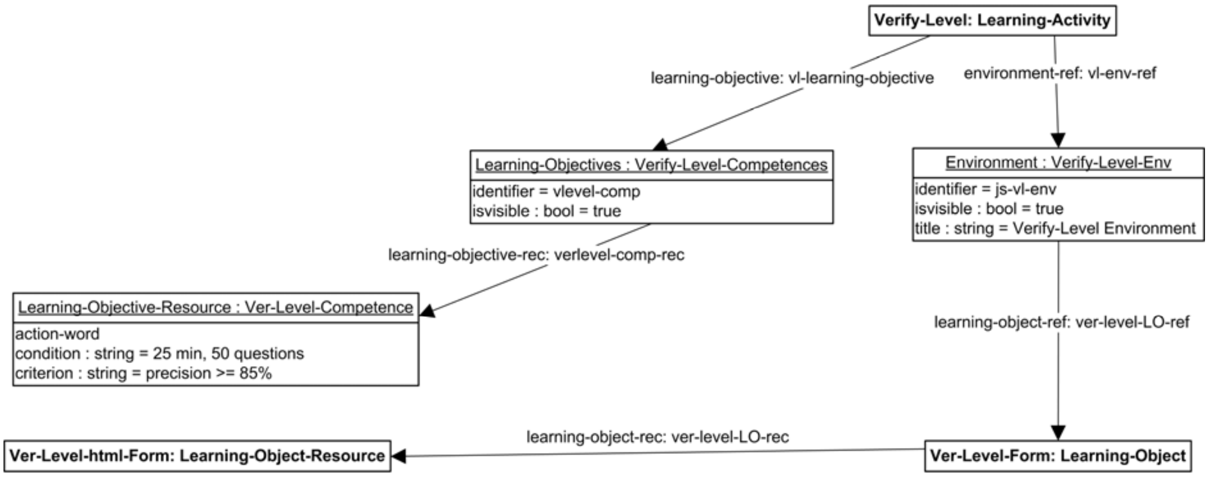


Figure 8. Definition of a learning activity of the Jigsaw example.

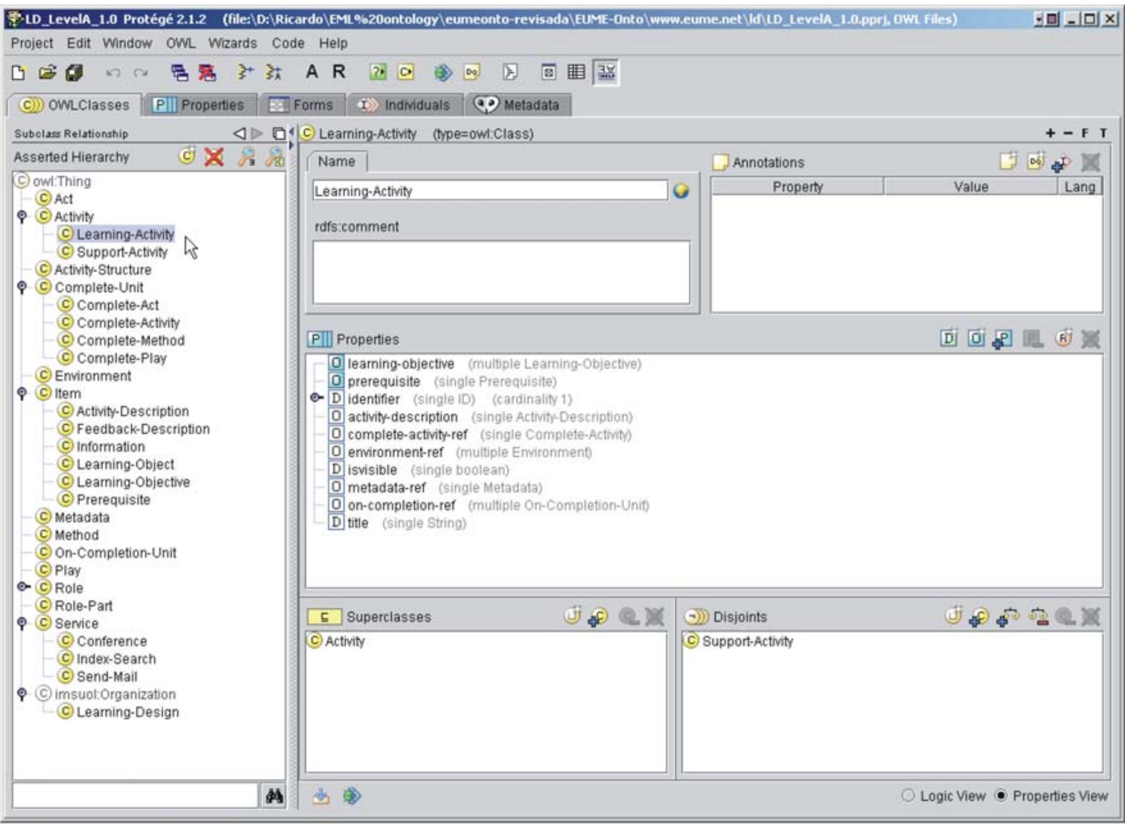
Construction and Use of the IMS LD Ontology

For the construction of the ontology we have used Protégé, an extensible, platform-independent environment for creating and editing ontologies and knowledge bases (Noy et al., 2000). As is shown in Figure 9, after describing the ontology at the knowledge level, the Protégé-OWL plug-in was used to export it to the OWL language (Dean & Schreiber, 2004) language, which is the W3C recommendation for the Semantic Web. The OWL specification of the ontology can be downloaded from *http://www.eume.net/ontology/imsld_a.owl*.

The IMS LD ontology is currently used in the EUME system, a learning management system oriented to support educational activities in the classroom (Sanchez et al., 2003), as a common language to manage the information about the educational resources available in the environment. The software architecture of the system is based on intelligent agent technology, and follows a multi-layer topology (Riera et al., 2004) with four different tiers: the Resource tier is responsible for low-level tasks (control of hardware/software); the Services tier is responsible for the educational activities; the Mediator tier is a common channel that routes every message between services and clients; and, finally, the Client tier contains graphic interfaces that allow the adaptation/personalization of contents/services to the learning environment and user preferences. The multi-agent EUME System was implemented in JADE, a FIPA-compatible middleware that facilitates both agent implementation and agent communication through message passing mechanisms.

The EUME agents use the IMS LD ontology as a common language to manage the information about the educational resources available in the environment. This is done by means of a set of JADE classes that were implemented to enable the agents *(1)* to manage the OWL code, and *(2)* then to generate messages in accordance with the FIPA-SL style sheet. Figure 10 illustrates the mechanism by describing how the description of a certain *Activity* is requested. The client agent (A/C) defines a template (FIPA-SL) according to this request, which is sent to the service agent (Search A/S) in the Services tier. After that, this agent generates another template to communicate with the specific resource to access the database.

1



2

```
<owl:Ontology rdf:about="">
  <owl:imports rdf:resource="http://www.eume.net/ontology/uol.owl"/>
  <owl:imports rdf:resource="http://www.eume.net/ontology/lom.owl"/>
</owl:Ontology>
<owl:Class rdf:ID="Method">
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:onProperty>
        <owl:ObjectProperty rdf:ID="play-ref"/>
      </owl:onProperty>
      <owl:minCardinality rdf:datatype="http://www.w3.org/2001/XMLSchema#int"
      >1</owl:minCardinality>
    </owl:Restriction>
  </rdfs:subClassOf>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string">The method
  </rdfs:comment>
 </owl:Class>
</owl:Class>
<owl:Class rdf:ID="Play">
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:minCardinality rdf:datatype="http://www.w3.org/2001/XMLSchema#int"
      >1</owl:minCardinality>
      <owl:onProperty>
        <owl:ObjectProperty rdf:ID="act-ref"/>
      </owl:onProperty>
    </owl:Restriction>
  </rdfs:subClassOf>
```

Figure 9. Protégé and OWL description of the IMS LD ontology

The EUME system is intended to facilitate the design and realization of different learning activities. The process begins with the professor specifying the learning design by using the out-of-classroom interface, a web interface that enables the introduction of Units of Learning and their corresponding Methods, Plays as well as other learning design elements. Figure 11 shows a screenshot of this web interface to illustrate the introduction of a number of Activities (Introduction, Verify-level and Present-Doubts) associated to the Presentation Act of a Java Programming Overview Play. For each Activity, a Powerpoint file was selected as a Learning Object resource. Once this design stage is completed, the learning activities are ready to be used in the classroom. Here, the professor uses a PDA interface, which contains the agent client to control the available hardware and software resources as well as to access the learning elements previously designed. After logging into the system (Figure 12 A), the EUME agents automatically retrieve the information from the database and show the Activities associated to the current Java Programming Overview Play (Figures 12 B-C).

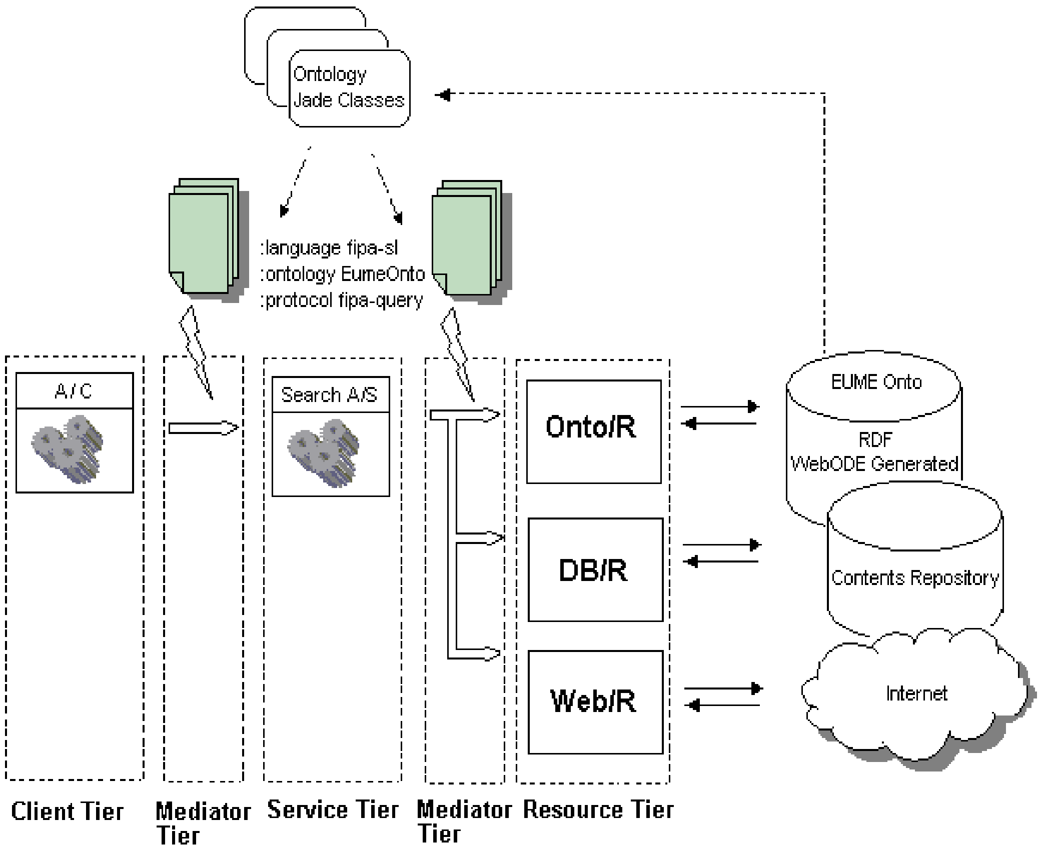


Figure 10. Mechanism to request an Activity in EUME

Finally, the LD ontology could be also used in a learning management system that implements the IMS LD specification following the XML-Schema language. In such a case, a translator from the ontology (expressed in OWL) into the XML-Schema representation, and vice versa, would be required. For instance, in a service oriented architecture, the translation operation could be offered by a Web service that would receive SOAP messages whose content is (part of) the ontology to be translated, and would send the result of the translation.

Discussion and Future Work

The IMS LD specification is expressive enough from the point of view of the learning process designers. Nevertheless, the informal specification of the IMS information and behavioural models increases the complexity of the IMS LD to be understood by programmers, as they are not usually educational specialists. This complexity could provoke misinterpretations and, even, errors when the IMS LD specification is incorporated to the development of applications.

The XML-Schema language is not enough expressive to represent al the knowledge compiled in the three models of the IMS LD specification. Mainly, hierarchical taxonomies, relation properties, and semantic constraints between the learning design elements cannot be represented in XML-Schema. To solve these limitations, the software system used to design and execute the unit of learning could codify the semantics of the specification in the programming language in which it is developed. This strategy has been followed by the Reload (JIST, 2004) and CopperCore (Vogten & Martens, 2005) environments to allow to users the design and execution of a unit of learning respectively. However, the main drawback of this approach is that the software programs are not *easy to maintain*, because of if the IMS LD specification is modified, it would be needed to re-codify the programs for including such modifications.

These two issues are solved with the learning design ontology. On one hand, as the semantics of the concepts is *precisely* defined, there should be no misinterpretations or errors when the instances of the concepts are created and managed in runtime. In this sense, new concepts, attributes/relations, and formal axioms have been identified and formalized in the ontology. It is important to emphasize that these add-ons neither change nor extend the IMS LD specification, but they *enrich* the description of the semantics of the IMS LD elements. On the other hand, as the semantics of the IMS LD specification is *explicitly* described, it is not necessary to codify such semantics in the development of the software program that allow to users to design and execute the unit of learning. Thus, general reasoner following the logic paradigm associated to the language in which the ontology is represented can be used to check the consistence of the unit of learning in both the design and runtime phases. For example, we can use a reasoner in description logic (like Pellet or Racer) to carry out inferences with the learning design ontology expressed in OWL.

The main drawback of the LD ontology is focused on the limitations of the expressiveness and reasoning capabilities of the ontology representation languages. For example, if the goal of an application is to guarantee that the edition and execution of the learning design satisfies the IMS LD specification, the OWL language would not be the best choice as it currently does not support the definition of axioms that check constraints between concepts. However, OWL could be an appropriate language for solving the interoperability issues between applications.

Figure 11. Interface used to define the Activities of the Jigsaw example.

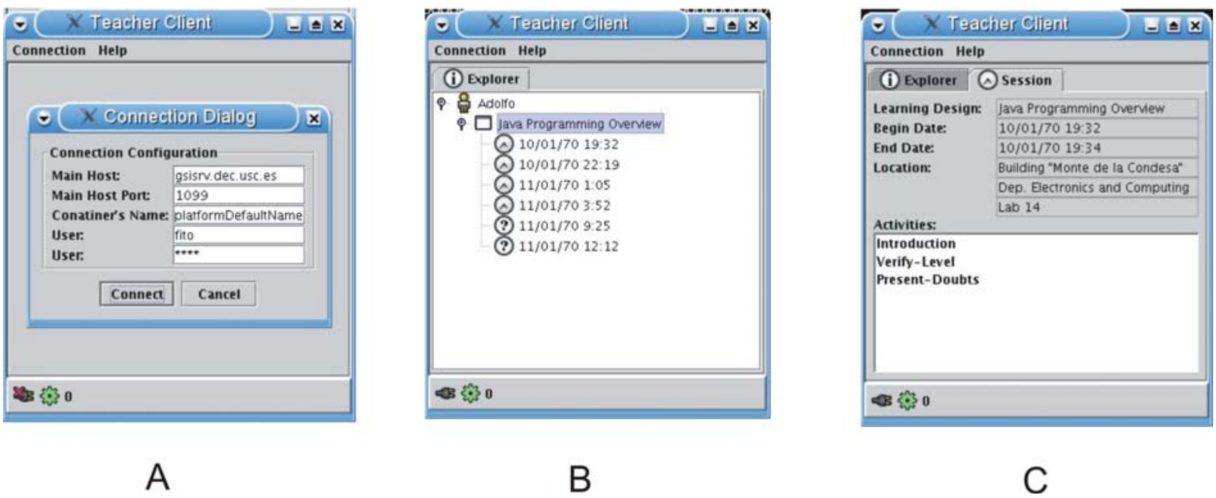


Figure 12. In classroom PDA interfaces.

As future work we have planned to translate the ontology axioms into SWRL (Horrocks et al., 2004), which is the language currently proposed to express restrictions in OWL. On the other hand, we are working on the extension of the ontology to include the concepts and axioms of the levels B and C of the IMS LD specification.

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COLLAGE: A collaborative Learning Design editor based on patterns

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ABSTRACT

This paper introduces *Collage*, a high-level IMS-LD compliant authoring tool that is specialized for CSCL (Computer-Supported Collaborative Learning). Nowadays CSCL is a key trend in e-learning since it highlights the importance of social interactions as an essential element of learning. CSCL is an interdisciplinary domain, which demands participatory design techniques that allow teachers to get directly involved in design activities. Developing CSCL designs using LD is a difficult task for teachers since LD is a complex technical specification and modelling collaborative characteristics can be tricky. *Collage* helps teachers in the process of creating their own potentially effective collaborative Learning Designs by reusing and customizing patterns, according to the requirements of a particular learning situation. These patterns, called Collaborative Learning Flow Patterns (CLFPs), represent best practices that are repetitively used by practitioners when structuring the flow of (collaborative) learning activities. An example of an LD that can be created using *Collage* is illustrated in the paper. Preliminary evaluation results show that teachers with experience in CL but without LD knowledge, can successfully design real collaborative learning experiences using *Collage*.

Keywords

IMS-LD, CSCL, Learning flow, Patterns, Authoring tool

Introduction

CSCL (Computer-Supported Collaborative Learning) constitutes a significant field that has drawn the attention of many researchers and practitioners (Dillenbourg, 2002). This domain is characterized by the coexistence of very different expectations, requirements, knowledge and interests posed by both collaborative learning practitioners and experts in information and communication technologies. In other words, CSCL is an intrinsically interdisciplinary field that implies a need for mutual understanding among the implied stakeholders. This need demands the active participation of all these stakeholders during the whole development cycle of CSCL solutions. Participatory Design (PD) approaches (Muller & Kuhn, 1993) propose a diversity of theories, practices, etc. with the goal of working directly with users and other stakeholders in the design of social systems. That is, PD methodologies define processes where users and developers work together during a certain period of time, while they identify the requirements of an application. In the CSCL case, it has been shown that it is not efficient enough to simply perform the identification and analysis of requirements for the development of CSCL solutions that support effective ways of learning. Collaborative learning practitioners also become active players in the process of customizing technological solutions to their particular needs in every learning situation. PD poses a new requirement that CSCL developers should tackle: how to obtain technological solutions for collaborative learning capable of being particularized/customized by practitioners that usually do not have technological skills.

This paper explores a solution to this problem: facilitating practitioners to play the role of designers of those technological solutions. Specifically, how PD can be enabled by providing authoring tools for collaboration scripts that can be automatically interpreted and executed by LMSs (Learning Management Systems). A collaboration script is a set of instructions prescribing how students should form groups and how they should interact and collaborate in order to solve a problem (Dillenbourg, 2002). In order for these scripts to be interpreted by computer applications, (Hernández-Leo et al., 2005) propose to formalize them using IMS Learning Design (LD). LD is an educational modelling language that enables the description of any learning process in a formal way (IMS, 2003).

Since there are several LD compliant systems such as those based on CopperCore (Martens & Vogten, 2005), e.g. Gridcole (Bote-Lorenzo et al., 2004), a practitioner can influence in the behaviour and the functionality of a CSCL system by providing a collaboration script formalized with LD. The problem is that LD uses formalisms (XML) that are not familiar to educators. This fact means that authoring tools are needed to facilitate the elaboration of collaboration scripts. Furthermore, those tools should guide practitioners through that elaboration process by using representations and abstractions that are easy to understand and use by them.

At the moment, there are several LD editors available or under development. Some of them are listed in Griffiths et al. (2005), and in Griffiths & Blat (2005). Depending on the type of user (technical expert, instructional designer, teacher) and their degree of pedagogical specialization, these authors classify the tools according to two dimensions:

- Higher vs. lower level tools (or distant from specification vs. close to specification). This dimension is related to the level of expertise in LD required by the user of the tool. That is, how much the tool interface is influenced by LD or how many LD details it hides.
- General purpose vs. specific purpose tools. This dimension deals with the pedagogical scope of the tools. Teachers using a clearly defined pedagogical approach (e.g. collaborative learning) would not need all the capabilities of the LD specification. This implies that authoring tools more tightly focused on that particular pedagogical approach might present to their users only the needed functionality, reducing significantly the complexity of authoring.

The audience on which we focus the problem of authoring collaboration scripts or collaborative LDs is composed of teachers that are collaborative learning practitioners (novice or not). They do not need to know LD and they are not supposed to be technologists. In this sense, a *high-level specific collaborative learning editor* will be appropriate. However, we are not aware of any authoring tool specialized in collaborative learning that is distant from the specification.

RELOAD (RELOAD, 2005), CopperAuthor (OUNL, 2005) and COSMOS (Miao et al., 2005) are examples of general purpose editors that are close to the specification. Their target audiences are LD experts that are not focused on a particular pedagogy. MOT+ editor (Paquette et al., 2005) and ASK-LDT (Karampiperis & Sampson, 2005) are intended also for expert learning designers rather than teachers, although they provide graphical representations that facilitate the authoring task to a certain extent. However, the type of editor practitioners (usually classroom teachers and not expert learning designers) need should be similar to the authoring environment provided by LAMS (Macquarie University, 2005). LAMS is a specialized editor because it offers a set of predefined learning activities, shown in a comprehensible way for teachers, that can be graphically dragged and dropped in order to establish a sequence of activities. Nevertheless, although LAMS is inspired by the LD philosophy, it is not LD compliant at the present time.

The rationale for specific purpose and high level tools is particularly evident in the case of the CSCL domain, considering the difficulty implied in modelling collaborative learning processes (Hernández-Leo et al., 2005; Miao et al., 2005). These difficulties are, among other things, related to defining groups or structuring the flow of collaborative learning activities. Moreover, if the collaborative learning process is structured in order to favour productive interactions, the potential effectiveness of the collaborative LD is enhanced (Jermann et al., 2004). Structuring the collaborative learning process in an appropriate way is also relevant since free collaboration does not necessarily produce learning (Dillenbourg, 2002) and because of the risk involved in incorporating collaborative learning structures into a class or a course (NISE, 1997).

To overcome these drawbacks, we advocate the use of patterns (Alexander et al., 1977) that reflect best practices in collaborative learning structuring as LD templates that can be applied to many collaborative learning situations (Koper, 2005). We call these patterns Collaborative Learning Flow Patterns (CLFPs) (Hernández-Leo et al., 2005), since they represent broadly accepted techniques that are repetitively used by practitioners when structuring the flow of learning activities involved in collaborative learning situations. CLFPs can be implemented in an editor as specific high-level collaborative learning structures built on top of LD. The main contribution presented in the paper is based on this idea: the provision of a specialised high-level collaborative learning editor that is capable of guiding teachers in the process of creating their own collaborative LD by starting from existing CLFPs. The tool is called *Collage*: *COLaborative LeArning desiGn Editor.*

Therefore, this paper is structured as follows: in the following section, our proposal of using CLFPs and LD to link collaborative learning practice with technology is introduced. It follows an analysis of *Collage*, which includes the description of the design process supported by the editor and its functionalities concerning the selection of CLFPs and the editing of the associated learning flow. Then, we illustrate the design process with an example and discuss the results of a preliminary evaluation study with real users. The paper ends with some concluding remarks and some pointers to future work.

Linking Collaborative Learning Practice with ICT

Summarizing what has been exposed in the introduction; our general aim is to link collaborative practice with Information and Communication Technologies (ICT). In order to achieve this, we exploit:

- The use of LD specification and high-level LD editors for practitioners (i.e. teachers), so the created LDs can be automatically interpreted and executed by an LMS. One of the aims of LD is the possibility to share and modify LDs in order to build better practice for e-learning (Griffiths et al., 2005).
- The utilization of a particular type of educational pattern (Goodyear et al., 2004) regarding collaborative learning flows to introduce design techniques in an LD authoring tool, enabling teachers to easily create potentially effective collaborative LD by particularizing and customizing the patterns.

Collaborative Learning Flow Patterns

CLFPs represent broadly accepted techniques that are repetitively used by practitioners when structuring the flow of types of learning activities involved in collaborative learning situations (Hernández-Leo et al., 2005). Thus, CLFPs can be understood as a way of collecting "best practices" in collaborative learning. These best practices refer to suitable ways of arranging participants in collaborative learning situations, sequencing types of collaborative learning activities, etc. in order to promote the achievement of a set of desired educational objectives. Among other advantages, they provide a way of communicating collaborative learning expertise to other (novice) practitioners: instead of trying to create their own collaborative designs from scratch, practitioners can reuse CLFPs as templates or guides for structuring their own collaborative situations.

Some examples of CLFPs are: TPS (Think-Pair-Share), Simulation, TAPPS (Thinking Aloud Pair Problem Solving) and Brainstorming (Aronson & Thibodeau, 1992; Johnson & Johnson, 1999; NISE, 1997). Table 1 summarizes two CLFPs. CLFPs can also be combined forming CLFP hierarchies. A collaborative learning situation may be designed according to several CLFPs in different levels. For instance, the "expert" phase of Jigsaw CLFP can be organized according to Pyramid CLFP.

Table 1. Summary of Jigsaw and Pyramid CLFPs

CLFP Name	Jigsaw CLFP	Pyramid (or Snowball) CLFP
Problem	How should the collaborative learning flow of activities be for a context in which several small groups should solve a complex problem/task that can be easily divided into sections or independent sub-problems?	How should the collaborative learning flow of activities be for a context in which several participants face the resolution of the same complex problem, usually without a concrete solution, whose resolution implies the achievement of gradual consensus among all the participants?
Solution	Each participant (individual or initial group) in a group ("Jigsaw Group") studies or works around a particular sub-problem. The participants of different groups that study the same sub-problem meet in an "Expert Group" to exchange ideas. These temporary focus groups become experts in the subproblem given to them. Lastly, participants of each "Jigsaw group" meet to contribute with their "expertise" in order to solve the whole problem.	Each individual participant studies the problem and proposes a solution. Groups (usually pairs) of participants compare and discuss their proposals and, finally, propose a new shared solution. Those groups join larger groups in order to generate new agreed proposal. At the end, all the participants must propose a final and agreed solution.

A necessary step before using CLFPs in an authoring tool is to represent them in a formal way. Our proposal for such a formalization, which has been reported in Hernández-Leo et al. (2005), is the basis for *Collage*.

Collage tool

Collage is a graphic-based high-level specialized Learning Design authoring tool for collaborative learning. It is based on RELOAD (RELOAD, 2005), which provides a plug-in framework. Collage is IMS-LD level A (IMS, 2003) compliant.

Design Process in Collage

The Best Practice and Implementation Guide included in the LD specification (IMS, 2003) details the different conceptual components of a system implementing LD. Figure 1 summarizes these modules, emphasizing the authoring problem and illustrating which functions are covered by *Collage*. Namely, *Collage* is not devoted to the enactment problem: instantiating LDs, binding participants to roles, interpreting an LD, etc. However, *Collage* allows the authoring of LDs. A Unit of Learning (UoL) is a content package (IMS, 2004) including an LD and a set of physical resources (content and tools) or their location. The resources that contain learning objectives, prerequisites, descriptions of activities and information about roles can be edited as text files in *Collage*. Other resources should be created with external editors.

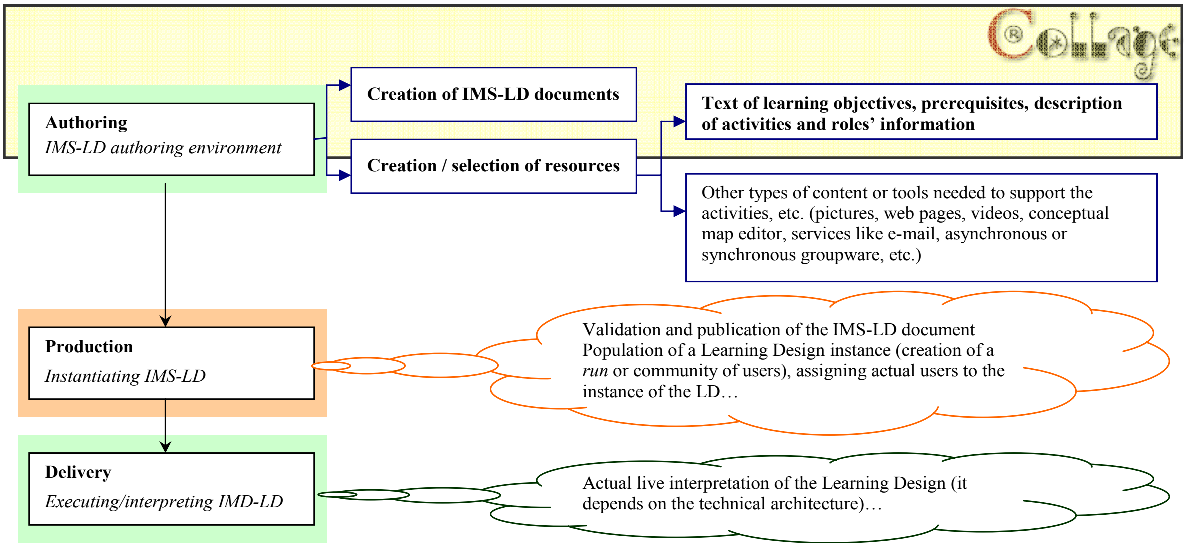


Figure 1. General modules of a system implementing LD

Designer's Guide, which is also included in LD specification (IMS, 2003), proposes the stages for creating a UoL. (Sloep et al., 2005) details these stages according mainly to three phases:

- Analysis of a specific educational problem. The result of this phase is a narrative description of what should be learnt, how it should be learnt as well as other characteristics of the educational situation.
- The narrative is translated into a UML activity diagram in the design phase. This diagram is the basis of an (XML) LD document.
- In the development phase the resources are created (if it is necessary) and added to the design, constituting a UoL.

These basic design phases are useful depending on the type of user that edits the UoL (designer, teacher, etc.) and, consequently, the type of authoring tool available. That is, different editors may support diverse design processes (Paquette et al., 2005). The more distant from the specification and specific purpose authoring tools are, the more valuable (for teachers) the supported design processes may be. This processes will be specially valuable if they provide a methodology for the analysis phase and enable teachers to understand and edit the UoLs (Griffiths et al., 2005).

The need for these kinds of processes is clearly evident in the complex CSCL domain. As it has been exposed in the introduction, planning collaborative learning designs to favour productive interactions is necessary. Strijbos et al. (2004) proposes a process-oriented methodology for the design of CSCL settings. The methodology implies that a conceptualization of the expected interaction is made explicit in advance and consists of six steps:

1. Determine which type of learning objectives should be specified.
2. Determine the expected interactions according to the specified objectives. It is related to the co-ordination of activities and the types of interaction promoted by the different types of activities (e.g. discussion).
3. Select task-types with respect to the learning objective and expected interaction. For example, if students have to solve a complex and ambiguous problem with no clear solution.
4. Determine how much structure is necessary to accomplish the learning objectives, expected interactions and task-types (e.g. privileged roles within an activity).
5. Determine which group size is best suited with respect to learning objective, expected interaction, task type and level of pre-structuring.
6. Determine how computer support is best used to sustain learning and expected interaction: face-to-face or computer mediated (synchronous or asynchronous).

Figure 2 shows the design process facilitated by *Collage*. The process is not strictly sequential. *Collage* provides guidance but it does not direct the user through a rigid wizard-style set of steps. The different tasks included in the *Collage* design process can be accomplished in the order preferred by the user.

The tasks included in the design process supported by *Collage* can be easily mapped to the steps indicated in the methodology proposed by Strijbos. Step 1 regarding learning objectives is partially performed in task *a* and completed in task *c*. Steps 2, 3 and 4 correspond to a large extent to the selection of a CLFP (mainly task *a*). Note that tasks *a* and *b* are repeated if the collaborative learning flow is structured according to a hierarchy of CLFPs (task *d*). Tasks *e* and *h* embody also step 4 as far as the structure of the interaction processes within activities is concerned. The description of an activity and the tool that supports it can represent a certain level of activity pre-structuring (e. g. a discussion activity supported by a simple chat vs. a chat with a structure dialogue interface that allows different roles). Task *e* clearly refers to step 5 (group-size). While determining the computer support (step 6) is accomplished in tasks *f*, *g* and *h*.

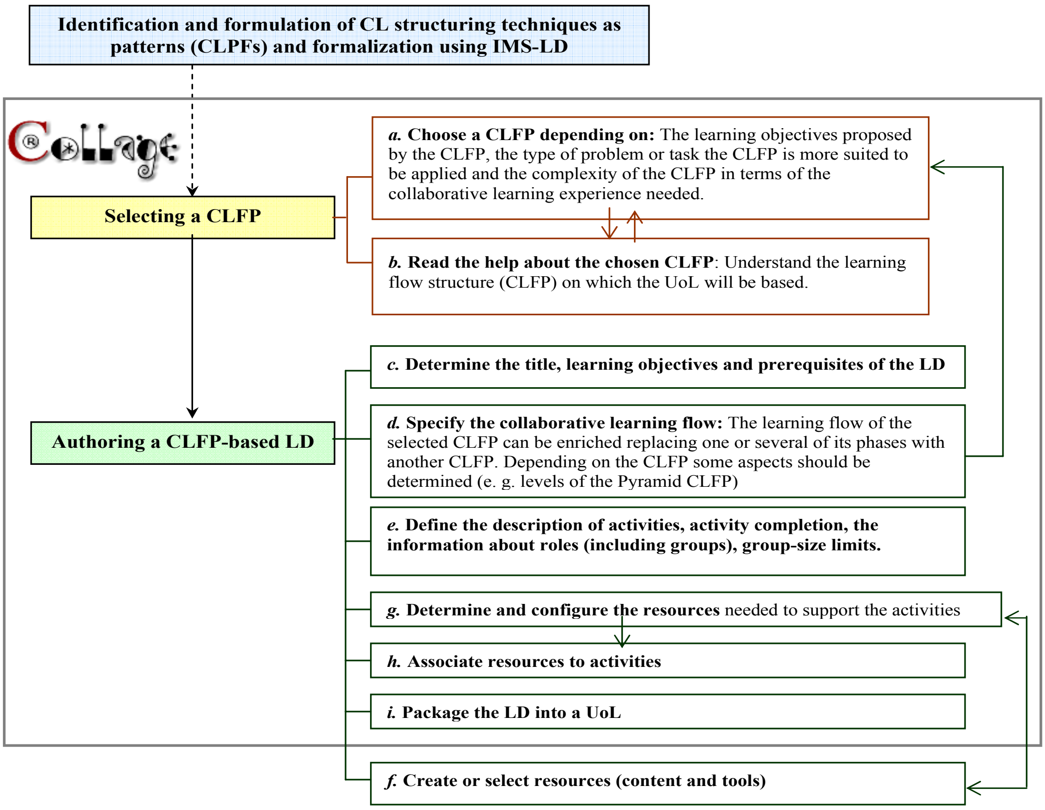


Figure 2. Design process in Collage

Collage and its implied design process represent an innovation to the phases recommended by LD specification in creating a UoL. Selection of CLFPs supports the analysis phase in which a collaborative learning situation is planned. It is necessary for teachers to know the structures (CLFPs) that are available in *Collage* in order to plan a feasible design to be created by *Collage*. On the other hand, the need for understanding those learning flows promotes the application of collaborative-learning best practices, i.e. reuse of CLFPs in their own educational settings. The design phase is highly simplified mainly thanks to the use of specific high-level collaborative learning structures (CLFPs) instead of raw LD elements. Moreover, the graphical interface provided by *Collage* facilitates the editing. That is, the UML diagram is not necessary (each CLFP has an intuitive diagram that represents the learning flow) and the XML code is automatically generated. Furthermore, available information about each CLFP and adequacy of CLFPs for educators enable teachers to understand and easily edit collaborative UoLs.

In order to offer a deeper understanding of these ideas, the selection of CLFPs and the authoring of LDs using *Collage* are analyzed in the following two subsections.

Selecting a CLFP

Collage provides a repository with a pool of CLFPs. The available CLFPs available at the moment are Jigsaw, Pyramid, Simulation, Brainstorming, TPS and TAPPS, but more CLFPs can be added. With the aim of facilitating the choice of CLFPs in *Collage*, a selection utility has been designed considering the following premises:

1. Potential *Colla*ge users may not explicitly know the collaborative techniques formulated in the CLFPs.
2. Users may not be familiar with pedagogical jargon. In this context it is more appropriate to indicate the meaning of the psychological term. E.g.: positive interdependence means that team members need each other to achieve a common goal.
3. Teachers should be able to select a CLFP, so that the LD they create is adequate for their educational purposes. Moreover, they should find CLFPs addressing their needs even if they do not know exactly the learning outcomes they want to promote.

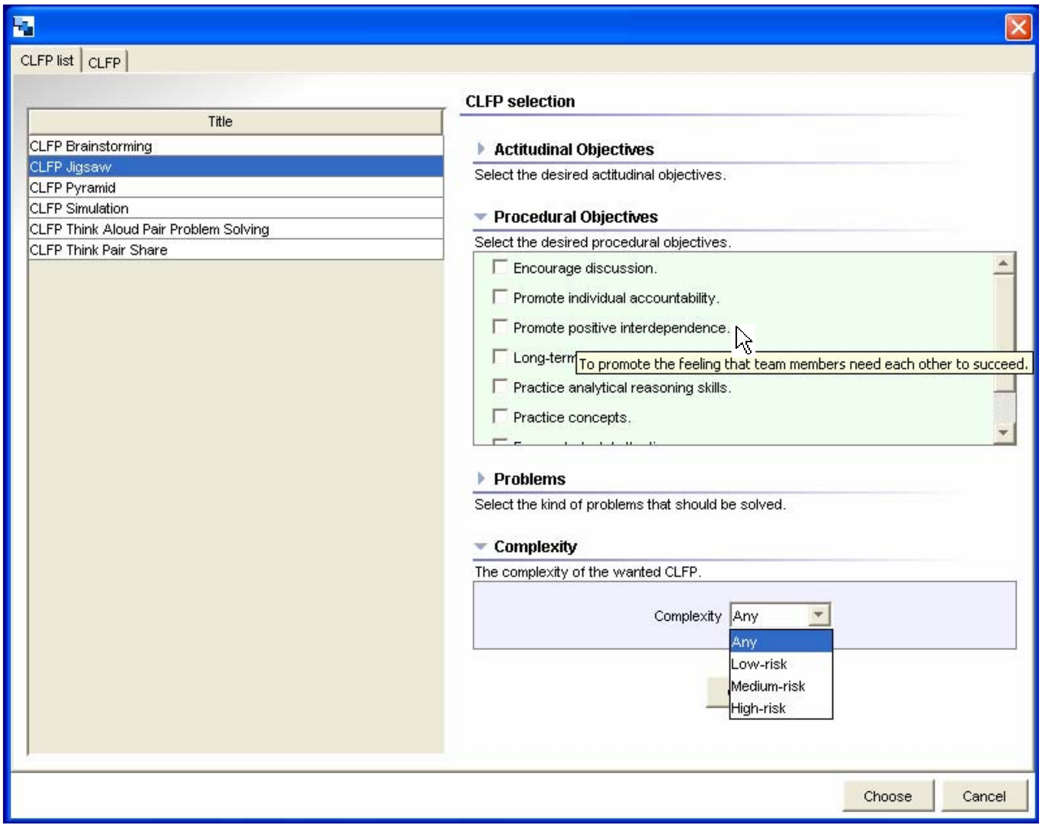
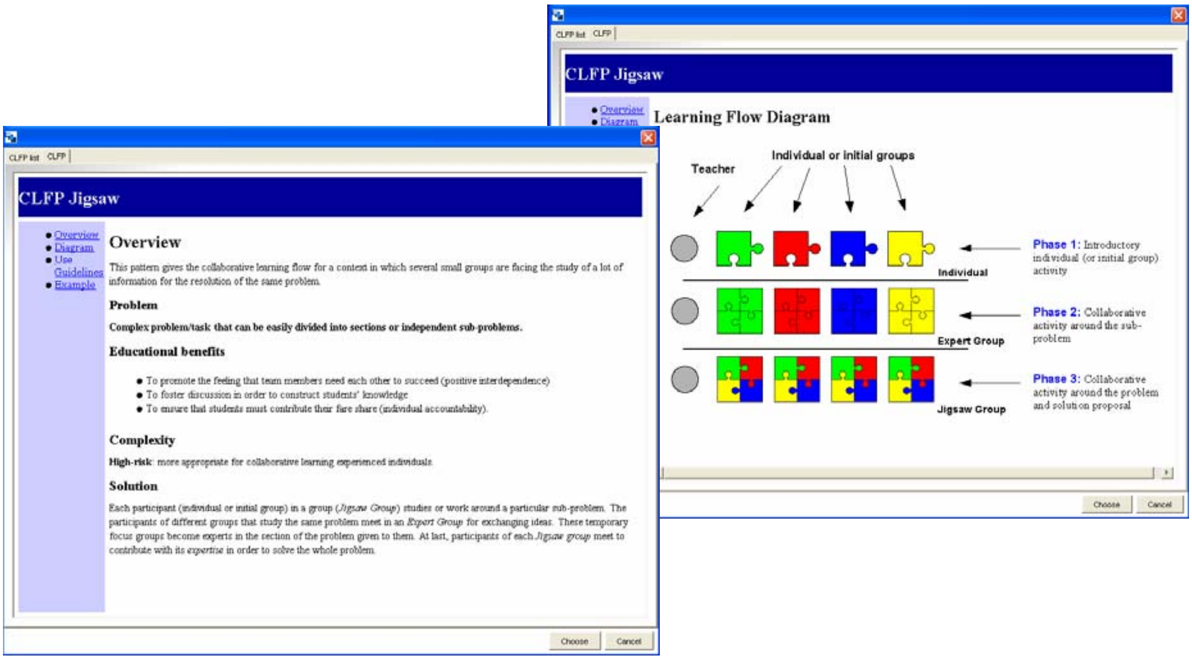


Figure 3. Collage CLFP selection interface

Figure 3 shows the interface of the CLFP selection utility, which allows the user to choose a CLFP directly or select one or several characteristics of CLFPs. The list of CLFPs displayed in the interface shows only the CLFPs that comply with the selected characteristics. These characteristics may or may not univocally identify a CLFP and they are retrieved from CLFPs' metadata, which include:

- **Learning objectives that the CLFP elicits**. They are related to the gain of conceptual knowledge, on one hand, and to the gain of meta-cognitive strategies, on the other hand (Miao et al., 2005). However, these objectives have been formulated in a simplified way (so teachers may understand them better) and classified in two types: attitudinal and procedural objectives. Attitudinal objectives are related to motivational and emotional competencies, while procedural objectives refer to the acquisition of skills. An example of an attitudinal objective is "to promote tolerance and respect" (Brainstorming CLFP). "To promote analytical reasoning skills" (TAPPS CLFP) is an example of a procedural objective. The fact that a CLFP can be selected according to objectives fulfils the two first steps of the methodology proposed in (Strijbos et al., 2004).
- **Types of problems that are best served with the CLFP**. It is equivalent to the selection of task type proposed in step 3 of Strijbos' methodology. For instance, the task type of Jigsaw CLFP is "complex problem that can be easily divided into sections or independent sub-problems".
- **Complexity or risk in terms of collaborative learning experienced needed**. Depending on the conditions in which the CLFP is to be applied or the experience in collaborative learning of teachers and learners, some CLFPs are recommended above others; e.g. Jigsaw CLFP is complex and is probably more appropriate for experienced participants (NISE, 1997).

Further information about each CLFP can be read by clicking on the title of a CLFP in the list of the selection interface. This information is displayed in a window that provides a navigation tree including four hyperlinks:



(a (b)

Figure 4. Help information about the Jigsaw CLFP: (a) overview, (b) diagram

Overview: apart from the learning objectives, the type of problem and the complexity of the CLFP, it contains the context in which the CLFP can be applied. It also explains the collaborative learning flow proposed by the pattern (see Figure 4 (a)).

Diagram: a graph illustrating the CLFP. The same graph is used in the authoring process (see Figure 4 (b)).
Use guidelines: indications and recommendations for particularization/customization, instantiation and execution (or authoring, production and delivery according to Figure 1).

Example: a sketch of a particular Learning Design based on the CLFP.

With this help information about CLFPs, teachers can be quite sure about the usefulness of a CLFP for their particular needs. In other words, they can understand the CLFP before reusing it and, consequently, they can be quite confident of the validity of the created UoL before running it in a real setting. The more significant functionalities of Collage that facilitate authoring of a CLFP-based LD are explained next.

Authoring a CLFP-based LD

Authoring LDs in Collage is actually a process of particularizing and adapting a CLFP according to the requirements of a particular learning situation. This includes tasks from c to i, as it is exposed in the recommended design process of Figure 2. The most significant functionality of Collage concerns task d: specifying the collaborative learning flow.

Once a CLFP is selected, the learning flow of the LD to be created is determined. However, it is necessary to state that it can be modified to a certain extent:

- Depending on the CLFP, configurable attributes are presented. That is, the user has to decide several aspects of the activity flow. A good example is Pyramid CLFP: it specifies the organization of activities (in a series of levels), and how participants will form groups and interact in each level, but the number of levels is not fixed. To create an LD based on this CLFP, users must first determine how many levels they want.
- Moreover, the flow of activities can be enriched by replacing phases of a CLFP with another CLFP. Whenever a new CLFP is to be inserted in the LD, the selection of CLFP functionality in *Collage* is presented. The result is a hierarchical structure of CLFPs. Although the actual number of CLFPs implemented in *Collage* is not large, there is no theoretical limit on the combinations of CLFPs that can be described.
- Apart from the configurable elements of each CLFP and the opportunity of combining several CLFPs, it is not explicitly possible to add or delete phases and activities. Nevertheless, *Collage* allows specifying an activity as not *visible*, which ensures that it will be ignored during the execution of the UoL.

Accordingly, Collage represents a trade off between generality and unrestricted design options vs. good reuse and particularization of CLFPs (and hierarchies of CLFPs) as well as an easy editing of collaborative LDs. Firstly, a simple intuitive graphical representation of each CLFP is provided. Secondly, users do not need to be aware of the existence and function of particular LD elements which are difficult to understand without knowing the specification. These elements are for instance activity-structure, method, play, act or role-part.

The tasks of describing activities and roles and associating resources to activities (tasks e and h of Figure 2) are facilitated by the use of forms, which are accessible by clicking on the graphical representation of each CLFP phase.

Discussion

One aspect that should be remarked on regarding our collaborative LD editor is interoperability. Tests have determined that CopperCore validates the UoLs created by *Collage*. Since *Collage* has been implemented as a new editor in RELOAD, the tool identifies whether a UoL has been created by *Collage* or by another editor implemented in RELOAD, and opens the UoL using the appropriate editor. However, the LDs created using *Collage* can be eventually opened by, a priori, any LD compliant editor. (Note that high-level or specialized editors, such as *Collage*, may need additional information about their representation in the authoring tool, etc.). This point leads the discussion to one of the limitations of our editor: it cannot be used as a viewer for any UoL. Other types of authoring tools should be employed to accomplish this goal and to change low-level elements of the LDs created by *Collage.*

Although *Collage* can be used by instructional designers, it has been specifically designed to be used by teachers. We support the idea that teachers should be able to intervene actively in the design process, especially if they do not have the support of specific instructional designers. A massive support of ICT in Education or specifically of LD requires the participation of teachers as real practitioners who know the reality of their context and could possibly assume the adoption of good practices (such as those reflected in CLFPs).

The initial adopted approach for the selection of CLFPs is simple. A more valuable approach could be, for example, the use of ontologies. Another limitation regards the addition of new CLFPs. If a new CLFP is to be included in *Collage*, the plug-ins related to the graphical interface for editing the collaborative learning flow must be implemented. Although there is no limit to the possible combinations of CLFPs that can be created, concatenations of CLFPs (adopting separate sequenced CLFPs) are not allowed yet. At this point, it is necessary to state that our LD editor approach is similar to LAMS in that it reuses predefined "modules" created with lower-level tools. However, *Collage* does not reuse at the granularity level of activities yet. It reuses the whole learning flow implied in collaborative learning best practices. There is definitely value in both approaches as they are complementary.

On the other hand, *Collage* supports only level A of the specification. In order to enrich and make more flexible the LDs that can be created using *Collage*, we are exploring the use of level B and C (IMS, 2003) in the formalization of CLFPs. That would enable the use of *properties* and *global elements* in order to define some flexible elements to be determined at run-time.

Creating an LD using Collage

CLFPs have been previously used in real contexts (Aronson & Thibodeau, 1992) without authoring tools. Now we can see how *Collage* can further expand such useful design processes, making them more efficient and effective. This section shows how a real collaborative learning situation can be designed with our editor. Besides, a preliminary evaluation of the tool has been accomplished.

Example: "Use of ICT in Education"

Description of the example

The example is connected to an experience that takes place within a course on "the use of ICT in education" at the Faculty of Education, University of Valladolid, Spain. This experience is one of the case studies included in the TELL project (TELL, 2005). This case study is a blended situation, where normal face-to-face activities are interleaved with technology-supported (distant or not) activities. It uses Synergeia system (ITCOLE, 2005). Synergeia combines an asynchronous component named BSCL (Basic Support for Cooperative Learning) and a synchronous component called MapTool. It mainly provides a shared web-based workspace in which documents and ideas can be shared.

The real scenario consists of 40 students (maximum). The example is an extract of the case study, in which students revise three topics in order to produce a deeper understanding of them. The analysis of the example is illustrated in Figure 5. The applied method is a combination of Jigsaw and Pyramid CLFPs.

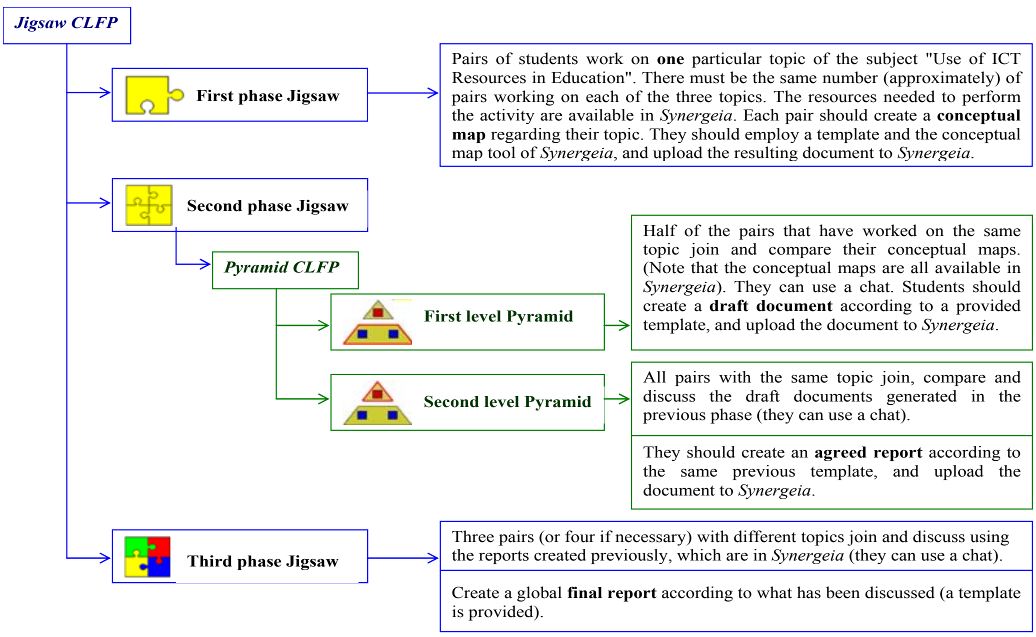


Figure 5. Analysis of the example based on Jigsaw and Pyramid CLFPs

Authoring the example with Collage

Figure 6 illustrates how the learning flow of the example can be edited using Collage. After selecting the CLFP base of the flow of activities, i.e. Jigsaw CLFP, the "Expert Group" phase is replaced with a two-level Pyramid CLFP. This is indicated with the circled "1", "2" and "3" of Figure 6. "4" points to the whole structure of the activity flow. This tree also provides access to any CLFP included in the hierarchical structure, thus the activities of each CLFP can be further particularized. The tasks of describing activities, roles, associating resources to activities, etc. are accomplished using a form analogous to the example shown in Figure 6. These steps are detailed in the worksheet included in the Collage user manual, which is available in (GSIC, 2005).

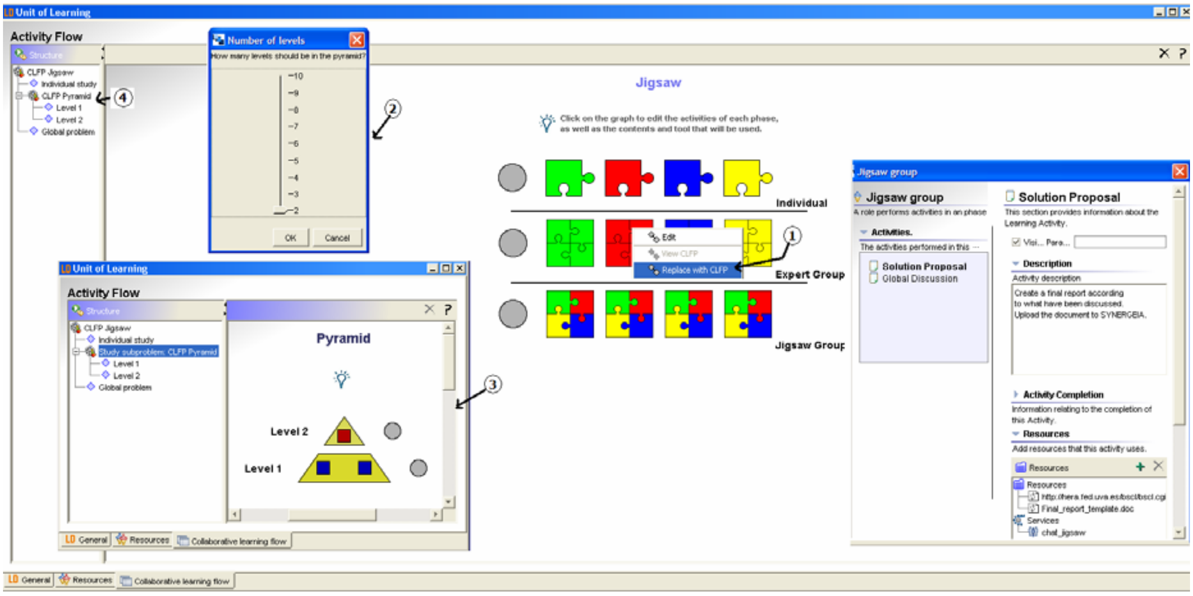


Figure 6. Editing the collaborative learning flow

Preliminary Evaluation Results

With the aim of obtaining some impressions about *Collage* from active teachers before using it in real situations, and in order to get some feedback for improving the tool, a preliminary evaluation has been accomplished at the present stage. We are not trying to provide definitive conclusions but a general idea of its usability in real practice. The conditions of the evaluation are the following. The three teachers of the course that correspond to the example shown in the previous subsection used *Collage* for the first time in order to create an LD describing this example (summarized in Figure 5) during 90 minutes. Two support persons were available for any question they may have.

The evaluation method that has been applied is a simplification of the mixed method proposed in (Martínez et al., 2003). Although it is devoted to the study of classroom social interactions, it includes quantitative approaches that allow us to detect general tendencies related to practitioners´ opinions and attitudes, and qualitative methods that help us to better understand these tendencies through the introduction of context issues and considering the participants' perspective (Stake, 1995).

In this sense, a small evaluation process has been designed in which the data has been built in the following way. During the first 15 minutes, practitioners were informed about the task and are provided with a user manual which includes a worksheet which illustrates the steps to create an example. During the experience, a qualitative evaluation expert made direct observations of the experiment so that difficulties were recorded. Then, each practitioner filled in an on-line questionnaire about the experience. Finally, an assessment of the LDs created was performed. The data has been examined (triangulated) considering the data (information of three teachers) and the techniques used to capture information (direct observation, questionnaire, analysis of the generated LDs).

To analyze the contributions generated during the process, a schema of categories has been established. The main categories are: user profile, general use of the editor, example creation and suggestions.

Regarding “user profiles” we can mention that they are teachers of the Faculty of Education that often practice collaborative learning but do not have LD knowledge. They are not technologist experts, however they usually integrate technological resources in their curriculum. They have not used any other LD tool. They are familiar with the techniques formulated in the CLFPs that *Collage* provides, which they find significant.

With regard to the “use of the editor” we can affirm that the way in which CLFPs are represented in *Collage* is considered quite adequate. The teachers’ original ideas about these techniques were rather similar to the way they are presented in *Collage*. We find arguments supporting the user-friendliness of *Collage*. For instance, they mention in the questionnaire that they do not have problems when selecting a CLFP or editing the title, objectives and prerequisites, a fact that is also commented on by the observer. Another conclusion is that the editor is considered to be intuitive: its graphical representations are quite useful for editing the flow of activities.

The main issues we can extract concerning “example creation” are as follows. First, they rate their experience in authoring the example as successful with minor problems that were easily coped with. In fact, CopperCore correctly validates the three UoLs, and the integrated LDs largely describe the learning situation of the example. However, all participants failed to particularize a specific activity, i.e., they do not enter a description or associate resources to the activity. This indicates the need to clearly specify the status of CLFPs and to highlight activities which have not been completed.

After the completion of the task, the opinions are quite positive: Teacher1 said, “It helps to think in terms of collaborative learning and its previous arrangement”. Teacher2 affirmed, “It helps to structure a complex learning design and promotes times and resources planning”. Teacher3 declared, “It enables the generation of contextualized learning processes according to the needs of each situation”. They also insisted on the usefulness of the provided CLFP help information. On the other hand, a drawback of *Collage* is the need for understanding CLFPs before the editing.

Further evaluation and discussion

Further evaluation has been performed. Two other teachers used *Collage* to try to design existing experiences they had performed in their classrooms. Both teachers belong to the research team that promotes *Collage*, although their knowledge of LD is minor and their first contact with the *Collage* tool takes place during this evaluation experience.
The first teacher teaches a course on "Operation, Administration and Maintenance of Communication Networks". He used *Collage* to design a two-hour experience consisting of a collaborative reading and discussion of a difficult long technical paper. Students are divided in groups of three and each group is organized according to the Jigsaw CLFP in order to read the paper. For the final step of the Jigsaw ("experts" share their expertise and agree on a final proposal) the teacher selects the Brainstorming CLFP. Final proposals simply consist of a list of the ten most important ideas found in the paper. Then, the different groups start working according to the Pyramid CLFP so as to agree on a final and unique list of 10 ideas.

The second teacher utilized *Collage* to design an existing approach in the graduate course of “Advanced Telematic Systems”, in which students try to propose a research question on a complex interdisciplinary field that involves several keywords. In order to achieve this goal, a Jigsaw CLFP is employed, where students in the expert group study and propose research questions related to some of the keywords. Then, students in the “jigsaw groups” try to merge the research questions.

The conclusions of the evaluation in these cases, which followed an analogous evaluation method to the one used in the preceding subsection, are quite similar to the results of the previous preliminary evaluation. However, some minor usability problems become apparent due to the fact that the teachers did not use any worksheet indicating the steps they should follow. They finally managed to create both UoLs, which were validated in CopperCore, and they were able to adequately shape their learning situations (one of the teachers affirms that *Collage* provided him with new design ideas). Nevertheless, they recognized a *Collage* limitation regarding the addition of complementary activities to the defined CLFPs and the possible need for making the description of CLFPs more flexible.

The designs employed in the evaluation study may be applied to different types of situations: synchronous and asynchronous, face-to-face and distant situations, with or without computer-supported activities or blended situations that mix different facets. Thus, *Collage* allows the creation of LDs for any combination of these environments. Furthermore, the durations of the diverse examples are quite different (from a two-hour to a month session).

Nevertheless, these evaluations are limited. Further evaluation with users that do not know the techniques formulated in CLFPs is especially needed. Additionally, running UoLs created by *Collage* in real settings with students is also desirable. These new evaluation studies might contribute towards a more consistent and thorough evaluation, which would address a limitation of current research in the field of LD.

Conclusions

This paper has presented *Collage*, a collaborative LD editor that is intended to be used by teachers. It allows an easy editing of UoLs by reusing and customizing best practices, which are formulated as patterns (CLFPs), in structuring the flow of collaborative and non-collaborative learning activities. The ultimate goal of an LD editor such as *Collage*, is to create significant, pedagogically sound scenarios that can be interpreted by players. *Collage* covers an essential part of the participatory design process and therefore it may form part of the whole life-cycle of an LD. *Collage* can be integrated into a system that enables creation, modification, adaptation, running and testing. In our case, we are in the process of integrating *Collage* into Gridcole (Bote-Lorenzo et al., 2004), a system capable of interpreting LDs and setting up the technological environment needed to support all the (collaborative) learning activities included in the LD.

In addition to accomplishing further evaluation studies with users of our University, evaluating *Collage* by an independent testing agency would be particularly useful. Although there are no easily available solutions, we will try to propose this issue within our participation among different projects.

Additional future work includes: adding more CLFPs and researching whether other types of patterns (e.g. activity patterns) can also be included in the editor. We may come to some conclusions in this sense using the work that is under way within TELL project, in which we are identifying patterns following a bottom-up approach, i.e., using real case studies as a starting point. In addition, we are currently exploring solutions to the lack of support for LD levels B and C in *Collage*. This problem has not been highlighted in the evaluation, perhaps because users designed scenarios that did not require a complete implementation through an LD player. However, it is necessary to study and evaluate this aspect in a larger variety of scenarios.

We have also planned the development of new functionality for *Collage*: the creation of a printed lesson plan of the UoL. It could be used to check if the created LD actually conforms to the collaborative learning situation analyzed for their particular situation, or to simply directly use the schema in a face-to-face situation without computer support. Moreover, we are exploring the possibilities and limitations of several alternatives for creating LDs that include both CLFPs and other structures that are not based on them. Furthermore, we expect to develop a management tool that will easily enable the creation of groups and the further binding of individuals to groups according to the CLFP hierarchy structure of an LD created by our authoring tool. *Collage* will be released under the General Public License.

Acknowledgements

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Authoring a full life cycle model in standards-based, adaptive e-learning

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ABSTRACT

The objective of this paper is to introduce a standards-based model for adaptive e-learning and to investigate the conditions and tools required by authors to implement this model. Adaptation in the context of e-learning is about creating a learner experience that purposely adjusts to various conditions over a period of time with the intention of increasing pre-defined success criteria. Adaptation can be based on an initial design, runtime information or, as in the aLFanet system, a combination. Adaptation requires the functionality to be able to interact with and manipulate data on the learning design, the users and the system and its contents. Therefore, adaptation is not an add-on that can just be plugged into a learning environment. Each of the conditions for adaptation have to be represented in a rigorous way. We will introduce a model based on a set of key learning technology standards that enables a structured, integrated view on designing, using and validating adaptation. For the author however, it appeared that the model is demanding both through the requirements imposed by the adaptation and the use of standards. We will discuss their experiences in applying it, analyse the steps already taken to tackle the complexity and come with additional suggestions to move forward to implementations suitable for a wider audience.

Keywords

Adaptive e-learning, Learning technology standards, IMS-LD, Authoring, Life cycle model, Agents

Introduction

Adaptation in the context of e-learning is about creating a learner experience that purposely adjusts to various conditions (e.g. personal characteristics and interests, instructional design knowledge, the learner interactions, the outcome of the actual learning processes, the available content, the similarity with peers) over a period of time with the intention of increasing success for some pre-defined criteria (e.g. effectiveness of e-learning: score, time, economical costs, user involvement and satisfaction). Adaptation focussed on one or more of the above mentioned conditions has been on the e-learning research agenda for well over three decades in different research topics such as Intelligent Tutoring Systems (Wenger, 1987), Adaptive Hypermedia (now Web-based adaptive educational systems) (Brusolovsky, 2001) and Multi-agent systems (Lin, 2005; Ayala, 2003; Boticario et al., 2000) often based upon an Instructional Design model or guidelines (e.g. Learning Styles (Felder & Silverman, 1988), and Concept Understanding (Leshin et al., 1992)) from which ‘rules’ are derived to implement the adaptation logic in an application specific representation.

Despite this research, a review of systems commonly used in universities and higher education (e.g. WebCT, Blackboard, TopClas, Ingenium, Docent, etc.) (De Croock et al., 2002) reveals that they are not explicit about the didactical methods and models supported, nor is it possible to explicitly express them, as methods and content are intertwined. Adaptation tends to be offered in the shape of mere predefined settings requiring extensive customisation. Also, at the design side the take-up is limited. In practice it appears to be difficult to use existing Instructional Design models outside the context of specialized teams. Koper (2003) summarizes the current practice in the following way. When teachers have to design or plan a lesson or course, there are several ways they can proceed. The majority of teachers employ an implicit design idea based on ‘knowledge transmission’. When preparing a lesson or course they think about the content, the potential resources (texts, figures, and tools), the sequence of topics and how to assess the learners. In e-learning practice this results in a sequence of topics with dedicated content without a learning design that can be inspected or processed.

The lack of adaptive learning environments or environments with adaptive features is partly due to the lack of sufficient support for adaptive behaviour in existing learning standards which leads to the unfortunate combination of higher initial costs and a low level of possible reuse due to proprietary models and representations (Paramythis et al., 2004). To cope with these issues, in the aLFanet project a framework has been designed that fits with the following requirements and makes extensive use of a combination of learning standards (for a detailed discussion see Van Rosmalen et al. (2005):

- it supports active and adaptive e-learning;
- it is open to the use of different types of learning models, alternative learning scenarios and to new components, such as agents;
- it offers a set of support services to different types of users (author, student and tutor).

For the authors this should imply that the design of adaptive e-learning is eased by giving them access to existing examples of adaptation and adaptive services that could be tailored to their demands.

The framework supports adaptation both based on an initial design and on information inferred from user interactions depending of the components activated. The adaptation offered builds on a combination of e-learning standards. This allowed building an open architecture composed of re-usable components. The central standard is IMS-LD (Koper & Tattersall, 2005). It enables the design of a variety of pedagogical models and separates the design of the pedagogical model from the content. IMS-LD (IMS-LD 2003) offers a semantic notation to describe an educational scenario in a formal way. At design time, a teacher or a design team can create or inspect a learning design model and use it in multiple courses. At runtime a tutor *or* agent (an autonomous piece of software), can interpret a learning design and students' progress and subsequent take action while a course is in progress, e.g. make suggestions to learners. To complement this standard, IMS-Metadata (IMS-Metadata 2001) describes the learning resource, which facilitates to provide the most appropriate learning resource to a certain learner in a certain situation. IMS-LIP (IMS-LIP 2001) is used for the representation of the user and IMS-QTI (IMS-QTI 2003) is used to generate adaptive questionnaires by applying selection and ordering rules based on the defined metadata. Everything is delivered in IMS CP (IMS-CP 2003) (Van Es et al., 2005) for a detailed overview and discussion on the standards used in aLFanet).

At the start of the project (spring 2002) the actual use of standards was limited. Standards that could have been useful, such as IMS-AccessForAll (IMS-AccessForAll 2004), did not yet exist. IMS-LD only virtually existed. It was first officially accepted at the start of 2003 and most systems and available experience focused on single, predominantly content related standards. Moreover, the compliance between standards was sub-optimal and only partially explored. As a result it was necessary to both build the tools to support the staff (authors, tutors, administrators), tools to support the learners in the actual leaning environment *and* design and implement solutions to work with the selected set of standards in an integrated way. In this paper we will in particular discuss the way in which we addressed the question of how to support the author in implementing adaptive e-learning. To do so in the next section we will first introduce the aLFanet system, its components and the types of adaptation they support. Next, we will discuss the authoring process including the life cycle model of adaptation as adopted in aLFanet. This model in combination with the available authoring tools forms the backbone of the authoring process. In the third section 'Pilot Experiences' we will discuss the experiences of the authors with the tools and the approach offered. We conclude the paper with a discussion of the results, in particular the usability issues identified, and come up with suggestions for a next cycle of research and development.

Adaptation in aLFanet

System Overview

The aLFanet system (Figure 1) has been designed as a services-based architecture with three layers (for a detailed description see (Fuentes et al., 2005)):

- The *Server* layer is in charge of integrating the services, the user front-end, managing the application security and tracing user interactions.
- The *Services* layer is a group of services, which provide the application functionality and main logic. It is open to include new (types of) services.
- The *Data* layer comprises the data management and storage.

In addition, and out of the three-layer architecture aLFanet provides authoring tools i.e. an IMS-LD- and an IMS-QTI authoring tool. The IMS-LD authoring tool (www.sourceforge.net/projects/alfanetat) allows the authors to create e-learning courses based on IMS-LD including metadata (IMS-Metadata) that are optional depending of the use of the various services. The IMS-QTI authoring tool (http://rtd.softwareag.es/alfanetqtitools/) supports the addition of metadata to externally defined IMS-QTI items and the definition of selection & ordering data in order to generate dynamic adaptive questionnaires at runtime. IMS-QTI items and other types of content are created with 'external' tools (Figure 4).

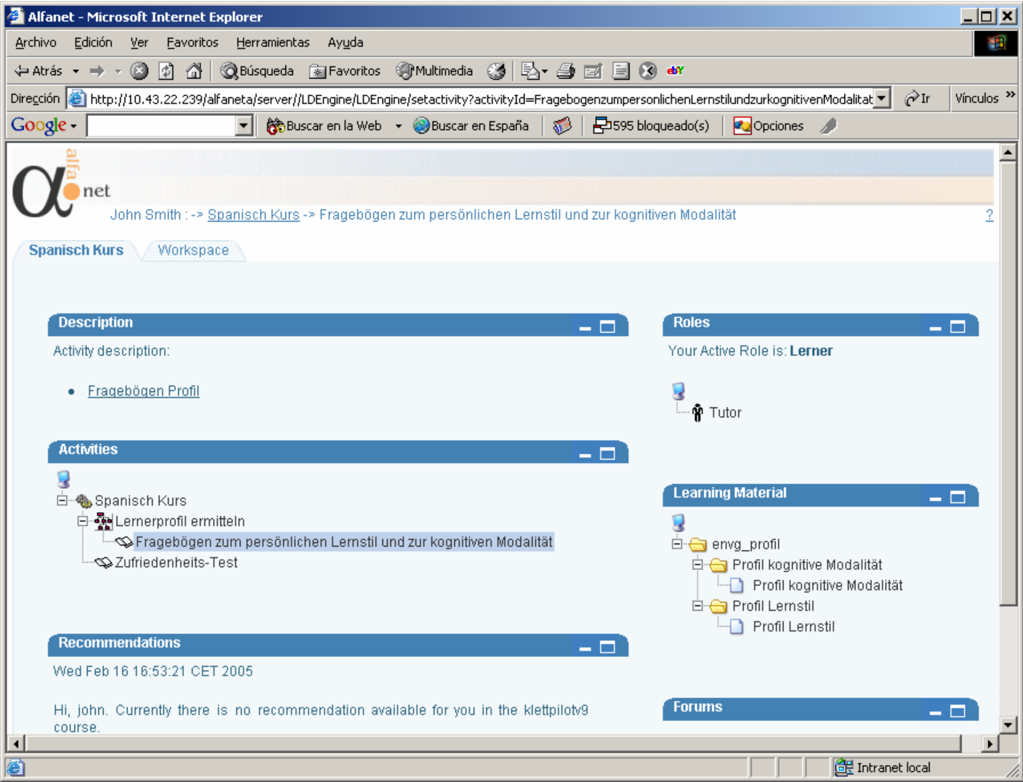

Figure 1: The aLFanet system: Workspace of the Spanish (German) course

The aLFanet system includes the following adaptive and interactive components in the Services layer:

- The Presentation module provides a personalised interface (the learner can select out of a number of presentation templates) and an adaptive interface (based on the learners' characteristics) for the different services that configure the platform. The adaptive presentation uses the information in the User Model, based on IMS-LIP and the metadata associated to the LOs to adapt the order of presentation of the LOs to the interests of the learner.
- The IMS-LD-engine, CopperCore (Vogten et al., 2005), provides the system with the functionality to execute UOLs (Unit of Learning) following an (adaptive) design modelled in IMS-LD. At the e-learning system level, the adaptation can be based on the UOL or the adaptation can be augmented by the other components. Information exchange between the engine and other components is supported through naming conventions. For example data synchronization between the IMS-LD and the IMS-QTI engine is based on the use of the prefix 'sync_qtiresult_' in the properties, which is recognised and followed up at the server layer.
- The IMS-QTI-engine (http://rtd.softwareag.es/alfanetqtitools/) provides the support for the interpretation and presentation of dynamic adaptive questionnaires defined in IMS-QTI. The questionnaires are dynamically generated based on the properties in the User Model (IMS-LIP) and the metadata of the QTI-items. For example a questionnaire may adapt to the knowledge level of the student.
- The Adaptation module (Santos et al., 2004) provides recommendations and advice to learners while interacting with a course based on the experience derived from previous users' interactions. It combines information from the user model (IMS-LIP), the general course structure (IMS-LD), the metadata associated to the LOs (IMS-Metadata) and the results of the questionnaires (IMS-QTI). The technological base of this package is a combination of User Modelling, Machine Learning and Multi-Agent Architecture. Examples of recommendations supplied by the Adaptation module are remediation advice to study specific materials, advice to contact learners with similar interests or problems, advice to study additional learning material for learners with high interests and alike.
- The Interaction Module supports individual and collaborative users' tasks in terms of interactive services (forums, file storage area, agenda, etc). They can be based on the course definition at design time (IMS-LD).
- The Audit module generates a number of reports derived from the actual usage of the system combined with data entered in the course design in IMS-LD. Examples are: the learners who studied a specific course; the

study path taken; the mean study time of an activity. The author can include additional data, e.g. 'planned study time' for an activity, in which case the system reports on the difference between planned and actual study time. The author can use the reports to close the design loop, this means to compare the anticipated use with the actual use and adapt the design if required.

Authoring Process

Once starting the design of a course (Sloep et al., 2005) in aLFanet, the author has to be aware in each of the design steps from analysis to evaluation what adaptation is required, what information on the learner is of relevance and how it fits with the platform components (Figure 2). In the analysis phase in addition to the regular questions the author has to ask if, e.g. for the reason of the effectiveness of the learning (to achieve a higher score or reduce study time or drop out) or to achieve a higher user involvement, the design should include adaptive options. The adaptation options are constrained by the instructional design, the additional data available and the analysis of the learner interactions. The adaptation can be realised by using a specific pedagogical template or by relying on runtime information that is collected by mining the learner interactions, but in any case the data required by the responsible modules have to be represented in a rigorous way depending on the required adaptation. Also if the authors want to make use of e.g. agent-based remediation as supplied by the Adaptation module, they have to add specific metadata to the learning activities, learning objects and test items. This information is used by the Adaptation module to trace which objective or competence has been addressed and at which level of complexity and which alternatives can be used to suggest the remediation.

For authors to be able to carry out the above introduced authoring process in an effective and efficient way they:

- have to be aware of the adaptation options (*transparent*)
- have to have a clear overview of the requirements -tasks, situation and data- to be able to make a decision on including the option (*affordable*: conceptual -being able to meet the requirements- *and* economical –balancing the perceived benefits with the additional work-)
- have to have the tools to include or 'code' the required adaptation (*facilitate*)
- ideally, should be able to validate the results (*verifiable*).

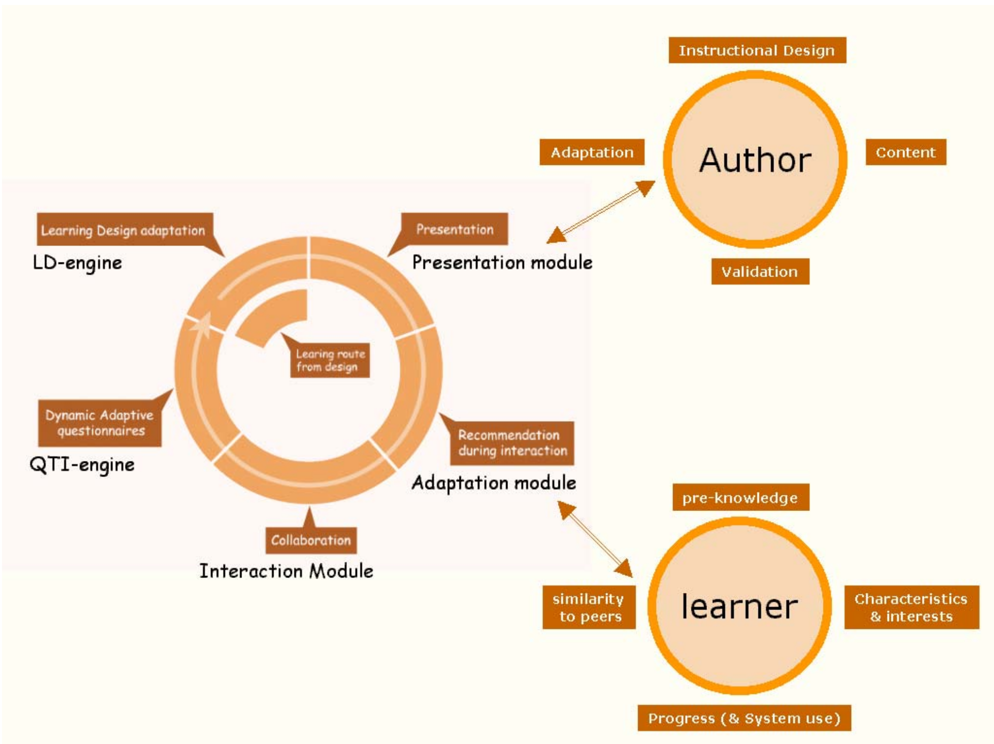

Figure 2: The aLFanet components and the type of adaptation they can offer related to the author's choices and the learner's profile

To cope with these demands the authors received a combination of tools and documentation including a description of the aLFanet life cycle model for adaptation (*transparency* and *affordability*), a template (*transparency*), an IMS-LD and IMS-QTI authoring tool and manuals (*facilitation*), and the access to the Audit module to support the validation (*verifiability*).

The description of the aLFanet life cycle model (Figure 3) includes a global description of each phase, its components and the requirements the Publication, Use and Validation have with regard to the Design phase. In the Design phase, the options for the other phases are prepared. In the Publication and administration phase, besides the normal functionality, tutors have the option to add static interventions triggered by events, e.g. based upon successful completion of a learning activity. Moreover they can define adaptive presentation rules so that e.g. the interface displays the course content following the learner's interest profile. Finally, students and tutors get assigned the roles and the rights they have in the course. The Use phase merely performs. It means the Presentation module, Adaptation module, the IMS-QTI engine and IMS-LD engine follow the design created in IMS-LD and within this context dynamically adapt and come up with recommendations based on the student interactions and their user model. Finally, the Validation phase closes the cycle. For the validation phase the system collects general data, e.g. the path through a course for a learner, and data requested by the author, e.g. whether the performance on an activity meets a pre-specified norm. The author can inspect the data and depending of their value decides if there is a need to reconsider the design.

The design contains the logic for the pre-designed adaptations and should provide the information upon which the runtime adaptation bases its reasoning. As a first step the author can select a pedagogical model template and apply it for the course at hand (note: other templates are possible, in the project however, we did offer only one) or start from scratch. The template bundles the results of research in instructional design (Felder & Silverman, 1988; Leshin et al., 1992) in a UOL modelled with IMS-LD. The objective is to ease for authors the complex task of designing their courses (and, see the quote of Koper in the introduction, improve the access to best practice and the take up of results of research in instructional design). In addition the author has to define properties and add metadata depending of the adaptation required. At this stage the author has to be fully aware of which type of adaptation is required and the corresponding data and actions expected. Part of the adaptation can be fine tuned at publication time, i.e. the choice to use static interventions or to adapt the interfaces to the characteristic of the learner. Also there is the opportunity to influence the course by assigning specific roles to selected learners. Nevertheless, all underlying data and the IMS-LD has to be prepared here and now. For example an Adaptive test (Figure 3) in the context of the template requires the definition of metadata to the test-items and history and selection rules (IMS-QTI authoring tool) and the definition of properties following a specific format. The latter is necessary in order to be able to exchange the results of the Adaptive test between the IMS-LD and IMS-QTI engine.

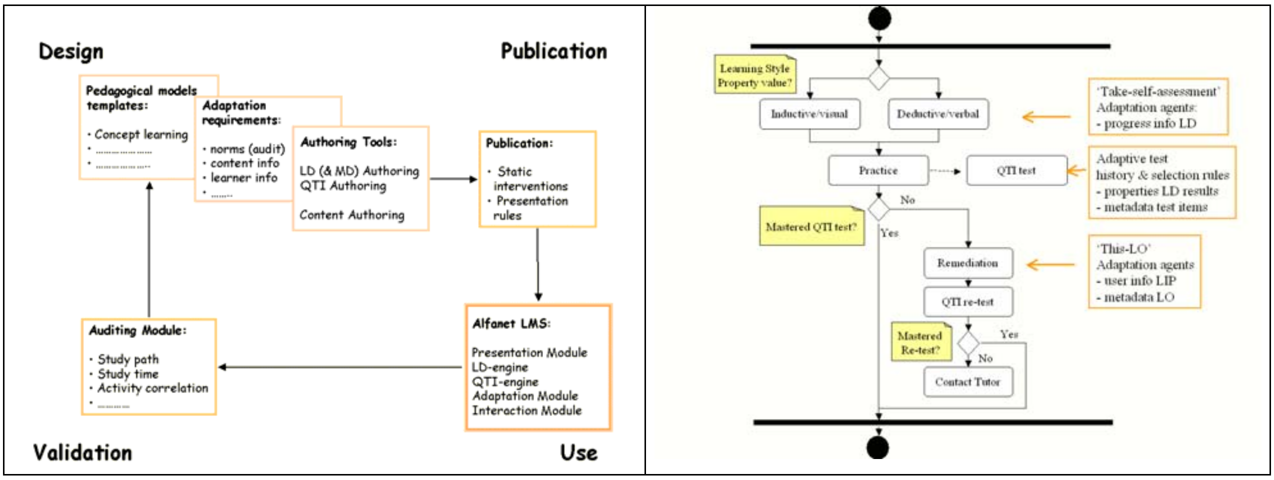

Figure 3. The aLFanet four step life cycle model: Design, Publication, Use and Validation and the applied pedagogical model template for 'Concept Learning'.

IMS-LD Authoring Tool

The technical authoring (Figure 4) in aLFanet consists of the following steps:

- The creation of learning content. This is not supported in aLFanet. The authors can use different types of documents such as HTML, text, PDF, etc..
- The creation of assessments. The question items must be created in an IMS-QTI compliant tool. Once the items are created, aLFanet provides the IMS-QTI Authoring Tool. It allows the definition of dynamic

questionnaires that can be adapted to each user depending on the user characteristics, course behaviour and questions' metadata that can be included while using the tool.

- The creation of the overall course structure (note the author can use the Concept Learning template) and, if required, additional adaptation scenarios based on the other services and/or modelled in IMS-LD. For instance to take advantage of the results of a questionnaire, the author has to add properties, conditions and metadata at the right place. The IMS-QTI assessment process is in charge of evaluating an exam and to generate a score value (or several score values) according to the item definitions. The IMS-QTI process has no information in order to determine whether an assessment has failed or not. The information about the required score for passing an exam is part of the design in IMS-LD. To synchronize the information of the assessment and the design it is necessary to generate scoring variables in the item definitions and in the IMS-LD design in order to determine whether the learner has passed or not.

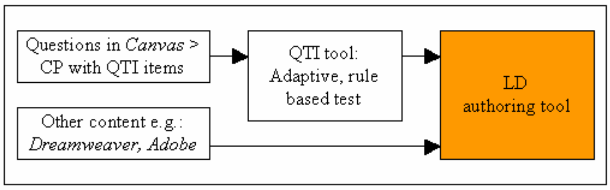

Figure 4: The technical authoring in aLFanet

As a consequence the most complex and most important part of the authoring takes place in the IMS-LD Authoring Tool (Figure 5). The authoring tool has been created in Groove (www.groove.net), a peer-to-peer collaborative environment which is, as such, particularly suitable for teams to create and share content over the Internet. Users can add tools to a workspace from a predefined tool-set, such as forums, shared files and calendars. Additionally, it is possible to integrate custom-made tools. The core part of the Authoring Tool is the IMS-LD Editor. This sub-module allows the user to create and edit courses in IMS-LD which can be published in the aLFanet LMS. The IMS-LD Editor closely reflects the structure of the specification with only some adaptations to enhance user-friendliness. It wraps the different concepts of the learning design in sub-structures in order to be more intuitive and conceptually organized to the user. Making sure that the user always saves a valid IMS-LD-file also at intermediate stages is another characteristic of the authoring tool. Moreover, it enables the definition of common metadata at the top-level, so that it only has to be entered once. Another useful option is that the author can get a tree overview of the course. The final result, a UOL can be saved as zip file following the IMS-CP specification (IMS-CP 2001). The reasons for building the editor in this way, closely resembling the original specification, are twofold. First, according to the requirements the editor should be able to deliver different types of learning models and alternative learning scenarios. Following the specification should avoid any limitations resulting from the tool. Next, when the tool was built, there were, besides the official documentation, no examples of lessons modelled in IMS-LD. Examples of sets of lessons modelled in IMS-LD have only been recently explored (e.g. Van Es and Koper, submitted). Therefore for the aLFanet authoring tool, being one of the first of its kind, the only related experience available was with editing EML, the predecessor of IMS-LD. This editing was done directly in a customised, general-purpose SGML editing tool (Tattersall et al., 2005). Nevertheless, although the actual IMS-LD code is hidden in the authoring tool, it still requires a solid understanding of IMS-LD and its interdependencies and, on top of this, from the specific requirements derived from the different components.

Pilot experiences

ALFanet has been built in three main cycles, in each cycle incrementally increasing its functionality. The first cycle ended with a base system operating on top of IMS-LD level A. The second version included an initial version of all components on top of IMS-LD level B. The third prototype offered an extensive set of adaptive features to choose from. Each cycle included an evaluation round with users from different backgrounds, companies, private and university students, and in different domains. More precisely two courses for university students i.e. “How to teach through the Internet“ (UNED) and “Communication technology” (OUNL), a “Spanish course for German Learners” intended for private students interested in learning Spanish (KLETT) and “Environment and Electrical Distribution” for internal staff training (EDP). The evaluation did focus on the full course cycle from course design to course validation (and subsequent updates) and included authors, tutors and students. Given the focus of the article we will only look at results of the validation by the authors (a complete description can be found in Barrera et al. (2005).

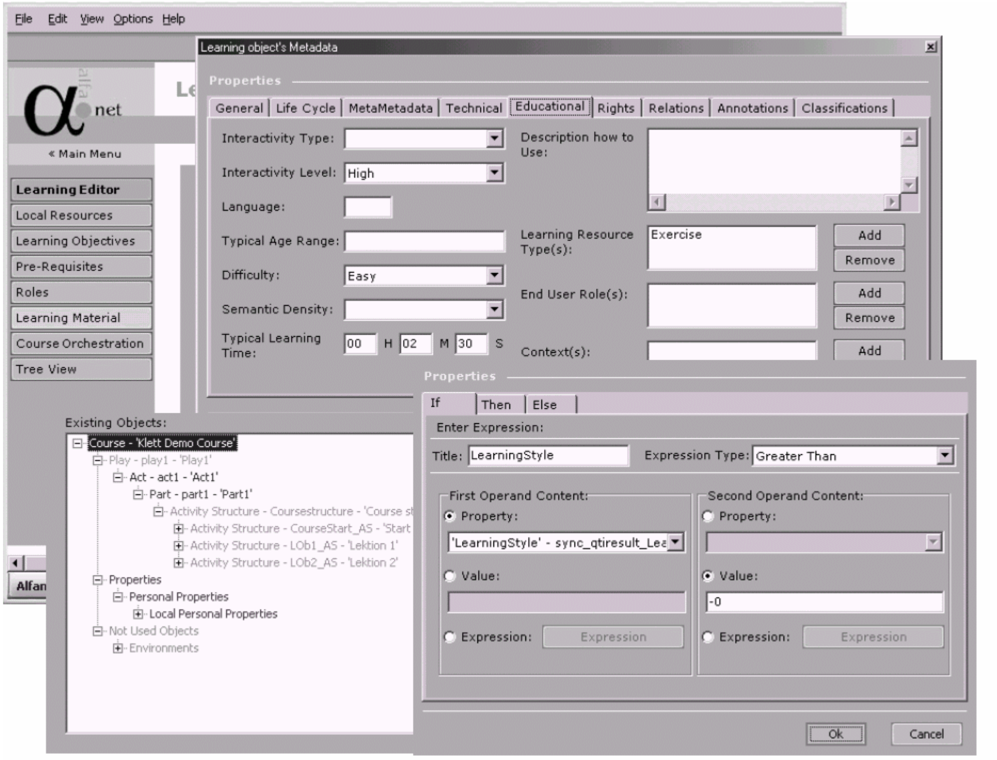

Figure 5. The main menu of the IMS-LD Authoring Tool and, on top the Learning Object Metadata, the Tree Representation and the Condition Editor window

Evaluation round one

The first evaluation round did focus on the authoring of IMS-LD level A. It contained a technical validation and a usability assessment. An IMS-LD expert did a technical pre-test with the aim to check that the functionalities provided by the authoring tool were conformant to the IMS-LD Information Model and to validate the resulting IMS-LD Code. In addition, a group of in total 8 authors were trained in IMS-LD and the use of the Authoring tool. All authors did have previous experience in creating at least one e-learning course. Only the university authors had background knowledge in the use of formal representations such as XML. The usability of the authoring tool and process was assessed with a combination of surveys and a questionnaire containing a diagnostic evaluation to identify usability problems and a subjective evaluation to get an impression on how the users felt about the software being tested. The overall feedback from the authors was that both usability and satisfaction were rated between low-medium, with the industry authors more close to low and the university authors more close to medium. Strengths and weaknesses mentioned were the following:

Table 1. Evaluation feedback round 1

STRENGTH	WEAKNESS
- The lesson designer does not have to learn XML to use IMS-LD. - User-friendly interface. - It is clearly structured. - The tool generates alerts when errors occur. - Provides the option to see a diagram of the course structure.	- It assumes a great deal of knowledge of IMS-LD, and therefore the Authoring Tool requires much training - The complexity of IMS-LD concepts - To create a course needs a lot of time due to the excessive number of items the author is required to insert. - Lack of logic in the workflow of the course. The editor is based on a technological view of learning design rather than an educational view.

Evaluation round two

For the second evaluation round the initial version of the complete prototype was available. Adaptive scenarios could be added making use of IMS-LD properties and conditions and by making use of the functionality offered by one of the system components. Based on an analysis of the first round two additional support items were developed for the authors: (1) a 'Concept Learning' template with documentation and (2) a description of the life-cycle model adopted, the components included and its consequences for the authoring process. The template should give the authors a well structured example showing the application of an instructional design example and its translation to IMS-LD and also, equally importantly, it should give insight to the developers in the creation and use of this kind of template. The life-cycle model and its description should make clear to the author why, where and what to include in the design in order to achieve the desired system behaviour for instance adaptive testing. The authors worked at their own pace to create their courses. On request, assistance was available for minor issues by means of a forum or for more complex questions by directly contacting a specially assigned expert. At the end of this evaluation round a questionnaire was used with the following findings:

Table 2. Evaluation feedback round 2

Issue	Findings
Template and life-cycle model	The template could be applied, but it was time consuming. Additionally, to use and integrate at the same time the guidelines to integrate the features of the other components e.g. to include an adaptive test resulted in a complex task.
Effectiveness	In principle the authors think that after extended experience with the tool they can work effectively with it. Nevertheless work is very time consuming due to the amount of data the author needs to process. They also complained that the work is too formalized: there is no integration of production and presentation (i.e. no What You See Is What You Get).
Efficiency	Authors said it is difficult to learn the use due to its complexity and the amount of components. On the one hand there are lots of options but on the other hand you need to be highly concentrated to be always aware of where you are and what to do.
Satisfaction	As a result of the critical aspects authors mentioned regarding effectiveness and efficiency the test persons were not satisfied working with the tool.

Evaluation round three

For the final prototype, only the number of adaptive features were extended. Besides some technical patches the authoring environment was the same as in the second round. The final evaluation did mainly focus on the learners, the authors did only update their course following the feedback of the second round and to include the new features of the system. In this round the feedback on the authoring process was derived only indirectly i.e. based on the problems the authors had to get their courses running and the corresponding support they received. The findings of the evaluation in the second round were confirmed. The authoring tool could be applied -more or less- for relatively simple straight forward UOLs. However, the use of the concept template and the use of adaptive scenarios supported by the various components caused problems, i.e. without support, none of the industrial authors were capable of fully implementing the desired scenarios. The number of steps required within the IMS-LD authoring tool and between the general content tools and the IMS-QTI authoring tool were too much. Also after missing just one step it was (too) difficult to trace, identify and solve the problem without support. It was possible for the available support staff to get the required data in interaction with the authors, so the data itself were not the problem. The amount of steps to be taken to enter the required data, the continuous awareness of which data to enter where and equally important what to ignore and finally the length of the feedback loop made it too complex to easily find omissions or mistakes. To test, the author first had to validate the UOL on IMS-LD conformance, next it had to be published and populated and finally to check the behaviour the author had to try out different scenarios – the latter a consequence of the use of adaptivity.

Discussion

The framework designed in aLFanet offers the opportunity to create a wide variety of active and adaptive e-learning scenarios. The framework has been built upon a set of leading learning technology specifications in order to assure future uptake and use of its developments. Authors can create their adaptive courses making use of pedagogical templates expressed in IMS-LD or of the adaptivity offered by the runtime services or they can create an adaptive course on their own from scratch making use of the properties and conditions in IMS-LD. At the end of the third evaluation round each of the pilot sites did include an interesting variety of -sometimes relatively complex- adaptation scenarios. The results achieved have two sides.

First of all, the results show that it is possible to support open and active learning and to create and support a set from simple to complex examples of adaptivity by combining the expressive power of IMS-LD combined with other standards supported by a combination of services. In this way the authors' work is clearly eased. They are not necessarily responsible to create the full design but they can take advantage of existing services, including agents, which can be used by taking care of in principle a simple set of assumptions. The approach taken illustrates that the complexity of the adaptation desired is not merely depending on IMS-LD (Towle & Halm, 2005). IMS-LD can be used successfully in combination with other services, including agents.

Secondly, however, despite the tools and documentation offered, only the university authors were capable of implementing the desired adaptation scenarios without support. The requirement that the design of adaptive e-learning is eased by giving the authors access to existing examples of adaptation and adaptive services (that can be tailored to their demands) has been worked out insufficiently. Though each of the authors, when asked, could deliver the appropriate data, actually entering them was only possible for the more skilled university authors. The challenge -not yet met- in aLFanet is to have the tasks to be accomplished not only clear at a general level but also to facilitate them at the micro-level concerning technical authoring. In other words, even when the tasks to achieve a selected kind of adaptation were judged to be *transparent* and *affordable*, the tools did not *facilitate* the actual technical authoring enough.

Griffiths et al. (2005), given the complexity of IMS-LD, distinguishes two types of users, which may be involved in the actual editing of a UOL i.e. the designers of UOLs and the adaptors or assemblers of UOLs. A similar distinction can be made between authors in aLFanet. Additionally, he distinguishes two dimensions to distinguish IMS-LD tools, i.e. the distance to the specification and whether the tool is general or special purpose. The need for tools in a specific quadrant obviously depends on the type of user and the context of use e.g. the complexity and variation in courses or the access to different types of skills. The aLFanet editor has correctly been categorised in the quadrant 'close to the spec' and 'general purpose'. With the exception of the content authoring, the same can be said about the rest of the aLFanet authoring process. However, the authors involved belong to both designers and adapters of UOLs with a significant difference in background and skills. In particular, for the authors with a non-IT background the usage of a complex tool in combination with the requirements to model complex adaptive scenarios appeared to be too much. The available support in the form of a template was seen as very useful but insufficient. Looking at the factors (table 3) that are commonly used to get an estimate of the usability of a system, it is clear that the lack of technical integration between the tools and consequently the lack of support to follow a well defined workflow negatively influences the ease of learning, the efficiency of use and the memorability. Even though the users claim that the user interface in itself is friendly and clearly structured (table 1), the lack of support and focus for the task at hand (e.g. to enable adaptive presentation) force the user to have knowledge about much more than they actually need for their task. It is not the information they have to enter (when asked they know) but how to get there and what to ignore that causes the problems. Additionally, the lack of direct feedback as discussed before, makes it difficult to learn and recover from errors.

Table 3. Factors of the user's experience that can be measured to estimate the usability of a system (see http://www.usability.gov)

Ease of learning	How fast can a user who has never seen the user interface before learn it sufficiently well to accomplish basic tasks?
Efficiency of use	Once an experienced user has learned to use the system, how fast can he or she accomplish tasks?
Memorability	If a user has used the system before, can he or she remember enough to use it effectively the next time or does the user have to start over again learning everything?
Error frequency and severity	How often do users make errors while using the system, how serious are these errors, and how do users recover from these errors?
Subjective satisfaction	How much does the user *like* using the system?

As a general rule of thumb one can argue that user-friendly editors i.e. 'distant from the specification' and 'close to the users concepts' and dedicated to a 'specific purpose' (Griffiths et al., 2005) should significantly increase the success of IMS-LD and the acceptance of the aLFanet system, in whatever order. This would be much in line with the mass uptake of the Internet following the development of user-friendly html-editors. However, it is not the only way ahead. Using the same vocabulary, IMS-LD, also has clear advantages. It facilitates the discussion in and between communities and it takes away the burden to develop and learn additional metaphors. The template used and the additional additive scenarios supplied in aLFanet were received positively, however, the workflow and the tools did not use the constraints, which could be derived from these to facilitate the authors. The selection of the template and the technical authoring were perceived as two distinct not integrated processes. For example, the authors have to construct and remember the right property names (with an additional prefix 'sync_qtiresult_') to enable data synchronization between the IMS-QTI engine and the IMS-LD engine and insert them at the right place. Yet another example, to make use of the automatic remediation recommendation offered by the Adaptation module, the authors only have to add the appropriate metadata to the learning material. However, this has to be done at the right place and from a metadata selection known by the Adaptation module. In both examples it should be relatively straight forward, once the global design choices are clear, to constrain the authoring with the consequences from the choices made. To achieve this, the authoring process should be layered in two steps. In the first step the author should select and set the boundaries of the initial template and the adaptation scenarios to be included. This also emphasises better the design nature of this step. The result should be a blueprint in IMS-LD accompanied by guidelines and explanations both at an instructional and a technical level. In the next step, the authoring process should make use of the constraints imposed by the blueprint and ease the work by limiting the choices to be made and making use of the information available.

Conclusions

ALFanet is (one of) the first e-learning environment developed on a set of five e-learning standards to provide adaptation in the full life cycle of the e-learning process. Each of the phases is influenced by the requirements of the adaptation capability provided by the system. The author provides at design time all data to provide adaptation. This information is properly stored at publication time and used to adapt the course during the execution, adapt the presentation to the learners interests, present the user a more focused learning path, provide the user with adaptive assessments (use phase) and to identify critical issues of the actual usage to the course authors that can be used to update the course (validation phase). Being one of the first to explore the combination of five standards within the context of an adaptive system obviously gave rise to a lot of unexpected challenges including technical ones i.e. standards not 'prepared' to work with other standards; functional ones i.e. how to apply these standards for the functionality required; and usability ones i.e. how to enable designers, tutors and learners to make the most effective use of the systems while at the same time guaranteeing a system committed to a complex set of standards and a variety of adaptive learning scenarios. The first two challenges have been met the standards are integrated and the system offers a set of adaptive features. The last one, the usability of the tools, however, is open for significant improvement. The expertise required to operate the current tools is not commonly available and is not likely to emerge on a large enough scale. The use of a template and a catalogue of adaptive scenarios were judged as useful by the authors but not translated sufficiently in the tools itself. To assure further uptake, future research and development should focus on how to clearly articulate the design choices and to translate the constraints and requirements imposed by these choices directly in the tools available to the authors to minimize complexity and to take advantage of information that can be derived automatically.

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Managing & re-using didactical expertise: The Didactical Object Model

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ABSTRACT

The DIN Didactical Object Model extends the approaches of existing Educational Modeling Languages introducing specifications for contexts and experiences. In this paper, we show how the Didactical Object Model can be used for sharing didactical expertise. Educational Modeling Languages change the design paradigm from content orientation towards process-/ activity orientation. Especially in the community of teachers and didactical designers, this development has gained attention. However, reusing learning scenarios requires applying knowledge management concepts to this issue. To adequately reuse learning scenarios, information about context and experiences must become available. Furthermore, supporting human-oriented knowledge management instruments are needed to facilitate the exchange and reuse process. The DIN Didactical Object Model, developed by the German Standards Body (Deutsches Institut für Normung, DIN e.V.), provides specifications for this. Additionally, an integrative concept for knowledge sharing and reuse is presented: the solution integrates business, learning, and knowledge processes into a common architecture using the Didactical Object Model to exchange scenarios. The presented modeling language will enhance the use of Educational Modeling Languages towards knowledge-based exchange of learning scenarios and experience sharing.

Keywords

Didactical Object Model, Educational Modeling Languages, Learning Design, Integrated Knowledge and Learning Management, Didactical Expertise

Introduction

The efficiency of the development of learning scenarios highly depends on the ability to reuse existing materials and expertise. The reuse of didactical concepts and methods is enabled through the use of formal specifications, such as IMS Learning Design (Koper et al., 2002; Koper & Olivier, 2004). The ability to model didactical concepts has changed the development paradigm from content orientation towards activity-/process-orientation.

However, there are certain requirements to successfully reuse didactical scenarios and expertise. The most important factors for the reuse process are 1) contextualization and 2) experience sharing (see next section). Therefore, we apply a holistic knowledge management approach to the reuse process in order to fulfill the requirements for successful reuse.

Based on these concepts, the paper identifies useful extensions to IMS Learning Design and ways to improve the exchange of didactical expertise. First of all, we will present a review of research on reuse of expertise from a knowledge management perspective. After a review of Educational Modeling Languages, the Didactical Object Model (Deutsches Institut für Normung, 2004) from the German Standardization Body is presented. It extends IMS Learning Design, adding the categories of Context and Experience, leading to a specification which enables the exchange of didactical knowledge and to manage this knowledge in repositories and platforms. The article closes showing a concept for an integrated system for business, knowledge, and learning processes based on the Didactical Object Model and Knowledge Management principles. However, even though this concept is not yet broadly adopted, first results in a comprehensive evaluation-process approved corresponding benefits to our theoretical work (see the section describing the Evaluation of the Model).

Reuse from a Knowledge Management Perspective

One of the most important goals of standards is reuse (Littlejohn & Buckingham Shum, 2003; Pawlowski, 2001). The IEEE Glossary (1990) defines reusability as "the degree to which a software module or other work product can be used in more than one computing program or software system". Extending this definition to the field of learning, education, and training, we consider reusability as the degree to which a component, object, or activity can be used in more than one learning scenario.

Reuse has been discussed in particular in the field of software engineering (Jacobson et al., 1997), especially for software components through different methods, such as patterns (Buschmann et al., 1996; Gamma et al., 1995). Reuse is discussed for different abstraction levels, such as systems, applications, components, or documents (Firesmith & Henderson-Sellers, 2001). In the educational context, the discussion focuses on learning objects (Wiley, 2000; Sicilia & García, 2003) and learning activities (Brusilovsky & Nijhawan, 2002; Koper & Manderveld, 2004; Karampiperis & Sampson, 2005; Reusable Learning, 2004). The broad variety of aspects of reuse is discussed in Littlejohn & Buckingham Shum (2003).

A result which is common in the field of reuse is that it is not sufficient to just provide codified knowledge as data (Snowden, 2002; Swan, 2003). This knowledge might not be understood or used (Szulanski, 1996; Lugger & Kraus, 2001). Therefore, the issue of reuse is a core knowledge management problem (Sridharan & Kinshuk, 2002; Benmahamed et al., 2005): to facilitate e.g., knowledge identification, knowledge acquisition, knowledge development, knowledge distribution/sharing, knowledge preservation, and knowledge use (Probst & Romhardt, 2000).

Consequently, we will show how experiences from knowledge management research can improve reuse. In particular, we focus on the improvement of reuse through scenarios. We show how general knowledge management concepts apply to E-Learning development processes and indicate how the process of knowledge sharing can be improved.

Knowledge Management in the Context of Reuse

During the past decade, knowledge management has emerged as one of the most important and widespread management issues. Knowledge management finds its origins in a desire to learn from mistakes and to hinder the "reinvention of the wheel" in organizations (Reeves & Raven, 2001). In the past decade, the importance of knowledge as a key resource has become well established (Drucker, 1994; Maier, 2002). However, exchange within the design of learning processes is usually limited to exchanging content. This means that without the context, the exchange is limited to information sharing rather than knowledge sharing. Therefore, context should be in the focus (Levy, 2003).

We use a definition of knowledge management by Maier (2002) which is on the one hand general enough to support all kinds of different knowledge areas and on the other hand regards management in a functional sense: "Knowledge management is defined as the management function responsible for the regular selection, implementation, and evaluation of goal-oriented knowledge strategies that aim at improving an organization's way of handling knowledge internal and external to the organization in order to improve organizational performance. The implementation of knowledge strategies comprises all person-oriented, organizational, and technological instruments suitable to dynamically optimize the organization-wide level of competencies, education, and ability to learn of the members of the organization as well as to develop collective intelligence" (Maier, 2002).

Although this definition has a slightly technocratic notion and it could be debated whether it is possible at all to stimulate individual competency development through external strategies, we still want to stress the above mentioned distinction. According to Maier's definition, two approaches to knowledge management exist: human-oriented (personalization) and technology-oriented (codification strategy) (Hansen et al., 1999; Lehner, 2000; Swan, 2003). These two approaches pose a different view on knowledge management and thus on reuse (*Table 1*):

- *Human-oriented/personalization strategy*: Knowledge is closely tied to the person who constructed it. Knowledge is mainly shared through direct person-to-person contacts. Information and communication technology (ICT) just supports people to communicate knowledge, not to store it. One example in our context is experience sharing within a community or within an organizational context in which activity patterns change and people share their experiences concerning learning scenarios. This means that didactical knowledge and expertise can never be separated from the context of its present or past use. Furthermore, it can also not be separated from the person who was responsible for a certain scenario.
- *Technology-oriented/codification strategy*: This strategy addresses computer technology and ICT: Information is (carefully) codified and stored in 'databases' where it can be accessed and used easily

(Hansen et al., 1999). The formal model of experiences is an example which could be used in the frame of such a strategy to supply people with a standardized set of information. Typically, a specification like Learning Design or Educational Modeling Languages would be used to codify knowledge about didactical activities and store it in an interoperable format.

Table 1 outlines the two above mentioned approaches and defines its basic assumptions by means of *strategy*, *comprehension of knowledge*, involved *parties* as well as corresponding *knowledge management system functions*, and enabling *ICT components*.

Table 1: Classification of Knowledge Management Approaches based on Maier & Hädrich (2001)

	human-oriented	**technology-oriented**
knowledge management strategy	personalization	codification
comprehension of knowledge	knowledge is contained in people's heads	knowledge is rather understood as stored, documented information, detached from employees
actors/roles	knowledge worker, networks, and communities of interest	authors, experts, information broker
important knowledge management system functions	communication and cooperation, allocation of experts, community-support, human capital management	publication, structuring and integration, search, presentation and visualization of information elements
relevant ICT components	community, expert network, experience sharing	formal experiences, analysis model

More recent knowledge management approaches suggest a *holistic* approach to knowledge management, bridging the gap between human-oriented and technology-oriented knowledge management (Lehner, 2000). Likewise, Hansen et al. (1999) identified certain strategy-mixes to implement a holistic knowledge management: A company pursues one strategy predominantly, e.g., personalization, and uses the second strategy, i.e., codification, to support the first. As outlined in *Table 1*, experience sharing is a main task for human-oriented approaches, supported by specific ICT functions. Therefore, we suggest a holistic approach, focusing on the human-oriented aspects and using technology-oriented specifications as supporting instruments.

As already mentioned, there are various barriers affecting knowledge management activities and thereby affecting the acceptance of knowledge management solutions. Contrary to various studies, Szulanski (1996) elaborates knowledge-related factors such as the recipients' lack of absorptive capacity, casual ambiguity, and arduous relationships between the actors. To overcome these barriers, it is important to understand that a fundamental purpose of managing knowledge is to create shared context (Fahey & Prusak, 1998). Furthermore, with a holistic, integrated, and standardized approach supporting redundant channels for knowledge sharing, reuse will increase *acceptance* (Maier, 2002).

Requirements for Educational Modeling Languages

Reuse is not only limited to exchanging didactical scenarios as technical specifications. Moreover, it should be possible to exchange didactical expertise. This problem is a typical knowledge management problem aiming at exchanging expertise, originally mainly for working processes. Therefore, we apply knowledge management concepts to exchanging didactical information (Adelsberger et al., 2004).

Educational Modeling Languages provide a base for the technology-oriented knowledge management view using structured, formal, and interoperable specifications. It is the exchange format for different applications, e.g., through the use of repositories. The specification itself is a format to exchange scenarios between systems. As shown above, this should be supported by human-oriented instruments, e.g., Communities of Practice (Wenger, 1998). However, establishing Communities of Practice requires a common understanding and terminology on the domain (Wenger & Snyder, 2000; Friesen, 2002). To facilitate this process, different instruments are used, such as structured case studies (JISC, 2005) or templates for experiences (Bergmann, 2002). Secondly, knowledge needs to be contextualized to enable reuse (Allert, 2004). Therefore, instruments should be able to identify similar contexts and connect those to the object to be reused.

As a conclusion, the main requirements for reusability are the ability to contextualize knowledge and to facilitate experience sharing:

1. Context: A knowledge intensive process is strongly related to the context in which it occurs. In order to find similar contexts, this should be modeled to enable better search and retrieval procedures.
2. Experiences: Describing a didactical scenario in terms of activities does not describe its success or failure, nor does it describe constraints or personal views. These are crucial for successful reuse. Connecting experiences with scenarios leads to the personalization of learning environments. Introducing such a category to Educational Modeling Languages means that didactical knowledge sharing and reuse is possible from the technology- as well as the human-oriented view.
3. Acceptance: A shared context for users must be created to overcome the knowledge management barriers.

Applying a holistic knowledge management strategy to a knowledge intensive process means that specifications should support the technology-oriented view and links to actors should enable a human-oriented view. By applying these concepts, two main conclusions can be drawn:

1. Specification Level: Specifications should enable the modeling of contexts and experiences (see the section "Model description').
2. Systems Level: Systems using these specifications (such as repositories) should enable interactions between all stakeholders involved in the process (see the section 'Integrating knowledge management and learning using the Didactical Object Model').

Educational Modeling Languages

This section analyses Educational Modeling Languages, concerning their usefulness and appropriateness to fulfill the requirements of knowledge management for reuse.

In recent years, modeling of educational and didactical concepts has become a focus area of conceptual and standardization research in Europe. The lack of didactical conceptualization in content-oriented standards like LOM (IEEE Learning Technology Standards Committee, 2002) and SCORM (Dodds & Thropp, 2004) led to this trend: the current representation of metadata such as LOM does not provide an adequate representation of pedagogical concepts (Koper, 2001; Pawlowski, 2001). Furthermore, there is no adequate mapping of content-oriented representation to a pedagogy-oriented representation. A variety of models have been developed in order to close this gap (Pawlowski, 2002). Specifications to represent and reuse pedagogical and didactical concepts and methods are summarized within the concept of Educational Modeling Languages. We will briefly summarize the main specifications in this area to point out their strengths and weaknesses regarding reusability. The main aspects, as identified in the previous section, are:

- Contextualization: The semantics of the object are understandable in different contexts. This also means that the context needs to be represented in a specification.
- Experience Sharing: The object is linked with information on actors involved in its use to enable experience sharing.
- Acceptance: The object is represented in a widely accepted format using a transferable specification.

Additionally, it is necessary that the specification covers all aspects of learning scenarios. Koper & Olivier (2004) distinguish specific requirements (completeness, pedagogical expressiveness, personalization, and compatibility) and general requirements (reusability, formalization, and reproducibility). In this article, we focus on the aspect of reusability, for an in-depth analysis see (CEN/ISSS, 2002; Koper & Olivier, 2004).

PALO (Rodríguez-Artacho & Verdejo Maíllo, 2004) is a language to model educational content. It consists of five layers: management, sequencing, structure, activity, and content. A wide range of complete learning scenarios can be modeled using *PALO*. However, the exchange and reuse is limited because the context of the scenarios is not described.

The *Tutorial Markup Language (TML)* (Netquest, 2000) is a markup language for the development of tutorial systems. Only a limited range of didactical scenarios can be modeled, such as questioning and problem-solving scenarios.

The *Instructional Material Description Language (IMDL)* (Gaede, 2000) represents structure, content, assessments, metadata, and a learner profile. The approach strictly follows an instructional design approach. Therefore, it restricts the pedagogical design. It is not flexible enough to model any given pedagogical approach.

The *Essen Learning Model* (Pawlowski, 2001; Pawlowski, 2002) provides a metadata approach for modeling didactical concepts. It mainly consists of three categories, to model *Context, Content and Didactical Concepts/Methods.*

Further concepts focusing on didactical issues are *Instructional Roles* (Allert et al., 2002) and *Web Didactics* (Meder, 2001) which provide a promising approach to combine content and didactical expertise. However, these specifications are not widely used in the community.

A widely used concept for the representation of pedagogical concepts is the Educational Modeling Language (EML) (Koper, 2001) which served as a base for the IMS Learning Design Specification (Koper et al., 2002; Koper & Olivier, 2004). Learning Design is a specification for modeling activities in learning processes and for relating these to the content. It is integrated into the Content Packaging specification (Smythe & Jackl, 2004). The main categories are:

- *Activities* are tasks in the learning process – they are aggregated in an *Activity Structure*.
- Activities are related to each other through the concept of *Methods*. Individual structures are generated through *Conditions*.
- User adaptation is possible through the use of *Roles* (e.g., Learner, Staff). Individual scenarios can be generated based on attributes (*Properties*).
- Within activities, resources (*Environment*) and *services* (such as Mail, Conference, Search, and Monitoring) can be referenced.

Koper & Olivier (2004) show that this language enables developers and designers to model complete, adaptable, and reusable scenarios. This model fulfills the main aspects to enable reuse. It is a formal, widely accepted model. However, it does not provide a semantically rich representation of the context. Reuse is only possible in certain settings depending on the context: either the context must be similar or adaptation mechanisms must be provided to reuse scenarios. To provide a concept for measuring similarities or to provide adaptation mechanisms based on the context, a category *Context* should be added to describe information about intended or applied context. Additionally, it is not possible (and not intended) to attach *Experiences* (Klebl, 2005) to a scenario which is common to most of the above mentioned approaches.

As a conclusion, IMS Learning Design is the most promising approach concerning acceptance and reuse. It should therefore serve as a base for further developments and extensions.

Didactical Object Model

With regard to the two main conclusions drawn in the section 'Requirements for Educational Modeling Language', we will firstly discuss the DIN Didactical Object Model to show the concept, its relation to IMS LD and to elaborate the proposed extensions. Secondly, the requirements for systems using this model will be derived in order to enable efficient reuse and experience sharing from a knowledge management perspective.

Model description

The objective of the Didactical Object Model (DIN DOM) is to enable efficient exchange and reuse of didactical expertise (Deutsches Institut für Normung, 2004). The model was developed within the German Standardization Body (Deutsches Institut für Normung, DIN e.V.) by a large group of experts and users, initiated by the project "Virtual Education in Business Information Systems (VAWI)". In this project, a group of 17 universities in Germany formed a consortium to develop an Internet-based Master program in Business Information Systems. The requirement of exchanging content, concepts, and corresponding expertise in such a setting is obvious. Therefore, the project focused on the use and development of standards to provide solutions for a complex, distributed E-Learning solution (Adelsberger et al., 2001). Additionally, experts were represented from a variety of educational organizations, such as traditional training institutions, content providers, content evaluators, human resource managers, and universities. From the analysis of existing models (see previous section), specifically the Essen-Learning Model, EML, Instructional Roles, and IMS Learning Design, the following requirements were identified:

- to provide a formal description of didactical scenarios, concepts, and methods,
- to support the planning, design, and development of didactical concepts and methods,
- to support the identification and measurement of didactical scenarios,
- to support the sharing and reuse of course concepts,

- to support the search and selection of adequate courses and modules,
- to support the sharing of experiences,
- to be consistent with other specifications, specifically IMS Learning Design.

It should be noted that it is not the goal to compete with existing specifications, such as IMS Learning Design. The DIN DOM is intended to provide useful extensions which could either be included in future versions of IMS LD or serve as application profiles or as separate specifications used by Communities of Practice. The model is therefore intended to widen the future use of IMS LD and to reach new target groups.

Based on the requirements specified above, the following levels and components were identified (see *Figure 1*):

1. *Context* describes the environment in which a scenario is intended to be used or has been used. The main aspect is the description of organizational aspects of the context. This representation describes for example, what kind of organization the scenario was used in or the educational objectives of the organization. Additionally, it describes aspects outside the organization, such as cultural issues or trends within a society which might be taken into consideration.
2. *Actors* denote the individuals, agents, or groups involved in the learning scenario. It consists of the description of actors themselves, but also their experiences concerning the learning scenario.
3. *Activities* are, based on Learning Design, the main aspect of the model, describing didactical concepts within an activity structure.
4. *Resources* describe materials and services to be potentially used in a learning scenario.

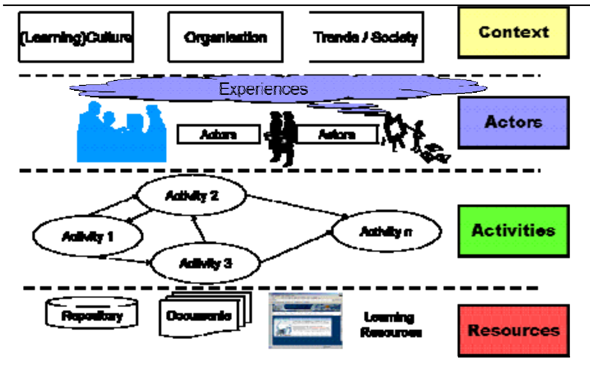

Figure 1: Levels of DIN DOM

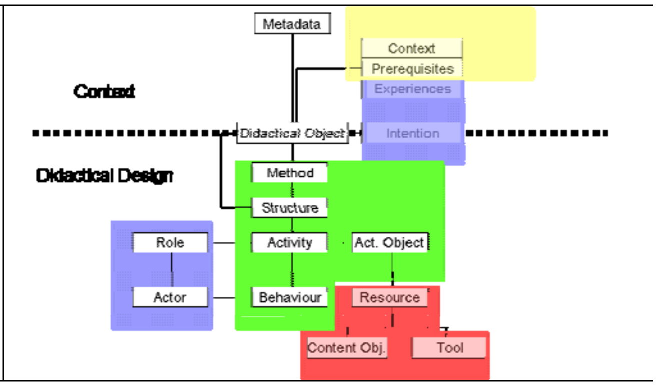

Figure 2: Structure of DIN DOM

The main concept in DIN DOM is the Didactical Object (see *Figure 2*). The *Didactical Design* describes the didactical, structural, and content aspects of a learning process/scenario. Methods contain the main information on the didactical concept, including structures, resources, and roles. The Didactical Design contains all elements and relations to describe a complete learning scenario. This part of the model is consistent to IMS Learning Design.

Through the concept of Didactical Objects the Didactical Design is related to the context and experiences. The context describes specific aspects, such as its situated embedding and relations to the Didactical Design. Actors play an important role in the model. On the one hand, actors are described concerning their preferences or competencies; on the other hand, they are directly connected with the Didactical Design modeling their intentions (ex-ante) and experiences (ex-post). The main components are summarized in the table below (*Table 2*).

Table 2: Categories of DIN DOM

Category	Description	Sample Attributes
Didactical Object	Node	
Metadata	Metadata record to describe the object according to Learning Object Metadata	General, Lifecycle, Rights
Context	Context of a Didactical Object describing the intended or current environment of usage	Name, ID, Kind (e.g., cultural, institutional, economic, location, technical), Type (e.g., planning, application)
Experience	Experiences made using a Didactical Object	Context reference, entity (e.g., actor X, organization Y), description
Prerequisites	Prerequisites for the use of a Didactical	Kind (e.g., technical, location, organizational),

	Object	description
Intention	Intention of developers how an object should/might be used	Kind, description
Method	Description of the didactical concept and its activities, based on IMS Learning Design	Name, kind, description, reference, task structure, task, role, resource
Global elements	Elements used by the Didactical Object	Actor, behavior, resource (e.g., content, service, tool)

The DIN DOM is an extension and therefore compatible with IMS Learning Design. The main extensions are the specifications of the context and experiences. It is possible to use DIN DOM as an application profile of IMS LD and vice versa. However, the main difference is the intention of usage: DIN DOM intends to facilitate knowledge sharing processes. The specification itself recommends practices for reuse. The use of each Didactical Object (e.g., in repositories) in a certain period should be related to the object, containing the context of a particular use scenario and the experiences with this context.

As a conclusion, the model facilitates design and development processes for the following purposes:

- Activities as the central modeling paradigm: like Learning Design, activities should be in the focus of design and development processes instead of content. Especially in the community of teachers and trainers, this can lead to more acceptance than content-oriented development since the development process is more similar to the typical development process teachers are used to (e.g., designing lesson plans).
- Reuse of scenarios: DIN DOM improves the processes of searching, retrieving, and reusing scenarios between systems and organizations.
- Knowledge Management and Experience Sharing: This focus issue was solved by introducing a structured representation of experiences for learning scenarios. Each Didactical Object will have a history of experiences attached. This history can then be used as a start for experience exchange and a basis for choosing adequate objects.
- Tools: One main aspect to increase acceptance is the provision of easy-to-use tools and templates to improve development processes. The specification is a basis for template and tool development.

Finally, it should be noted that the specification itself only covers the technology-oriented perspective of knowledge management. Therefore, it is important to utilize the possibilities of the specification by adding human-oriented knowledge management instruments. In the next section, we will therefore show a concept for integrating technology-oriented and human-oriented aspects.

Integrating knowledge management and learning using the Didactical Object Model

The Didactical Object Model is only a starting point to enable the reuse of scenarios. It is of vital importance to embed the usage of the model into an integrated architecture and process of knowledge sharing in all phases.

The integrated system should include systems which support processes in different situations. Such an integrated system should support processes directly related to the production and use of learning scenarios and to the core business processes of an organization. Additionally, an integrated knowledge management system should support problem solving processes and the exchange of expertise. Finally, corresponding learning systems support processes to develop competencies necessary for the business process. A single entry point should integrate these systems. As an example, an Electronic Performance Support System (EPSS) could provide access to all systems involved (Grey 1991; Raybould, 1995; Adelsberger et al., 2004). It should provide personalized, adapted information which is derived from the related systems (see *Figure 3*).

From a technological point of view, the Didactical Object Model is the main exchange format for such a system: It serves as representation for didactical scenarios (planning system, learning system), context (planning system and knowledge management system), and experience (knowledge management system). The personalization is based on context and actor information from DIN DOM.
From a human-oriented point of view, the specification is the starting point for interaction. Users will contact other users, based on intentions and experiences. However, the cooperation and communication environment must be part of an integrated system.

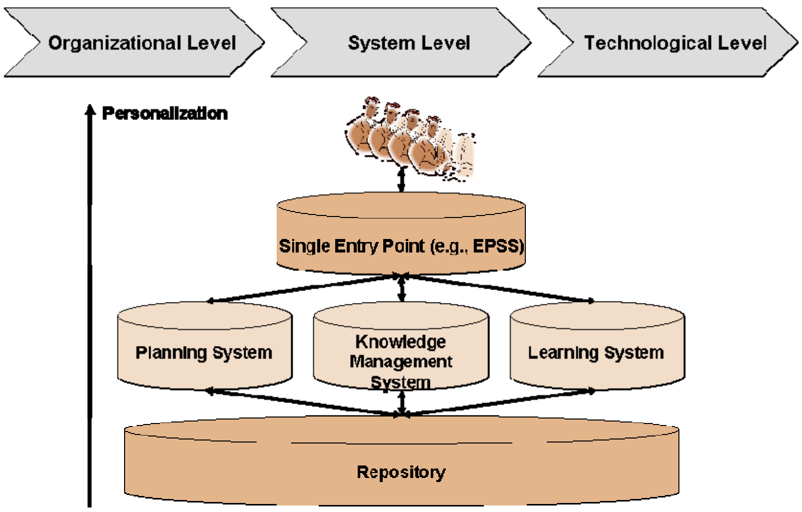

Figure 3: Integrated Architecture

Consequently, the processes of usage must be integrated: In a workplace environment, various process classes can be distinguished: e.g., Production Processes, Knowledge Processes, and Learning Processes (see *Figure 4*).

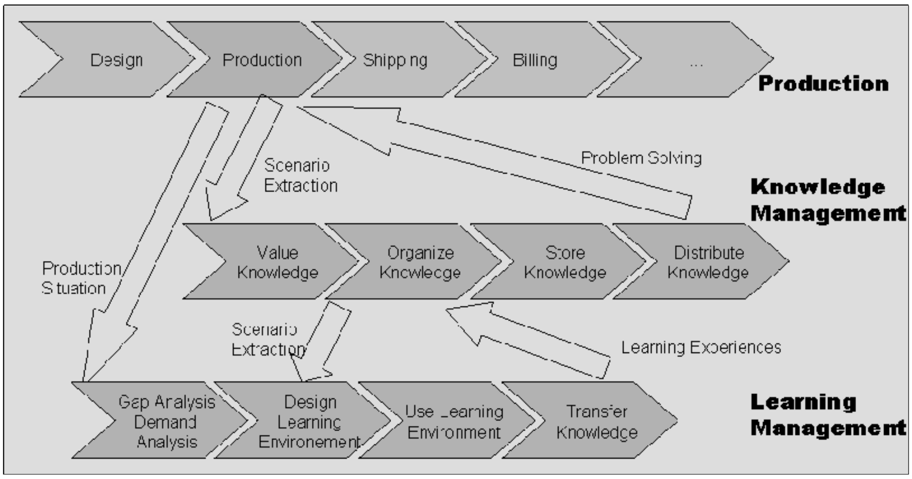

Figure 4: Knowledge-supported processes

Synergy can occur in various situations, e.g., within production, learning, and knowledge processes respectively in the corresponding systems, i.e., planning system, knowledge management system, and learning system (see *Figure 3*). With regard to DIN DOM, we focus on the exchange of information concerning (learning) scenarios and experiences.

- *Production Process and Knowledge Management Process:* In the production process, the user only uses directly related information systems, such as shop-floor information systems. In case of problems (e.g., delays, machine breakdown), the knowledge management system is used. The problem scenario represented using DIN DOM is transferred to the knowledge management system. If there are solutions, the production process is continued. If not, a new problem scenario is generated, providing solutions for future problems after the problem is finally solved.
- *Production Processes and Learning Processes:* The production situation should be continuously monitored by external and internal evaluations. The results should be the basis for a continuous gap analysis, identifying competencies and skills to improve the production process. The situation can be modeled (e.g., as the base for a case study) using DIN DOM. The learning process will be started and performed, leading to an improved production situation.
- *Knowledge Processes and Learning Processes:* Developing real life scenarios usually requires enormous resources. Combining learning and knowledge processes, real scenarios can be derived from the knowledge management system if both systems use DIN DOM as the representation format. Learning experiences can

also provide suggestions for problems arising in the future and should therefore be stored in the knowledge management system.

Integrating the above mentioned system classes on the *specification level* as well as on the *systems level* (see the section describing the Requirements for Educational Modeling Languages) allows a flexible organization of a knowledge-oriented workplace. Problems can be solved directly, whereas workplace-oriented learning is also facilitated. Particularly, the direct relation of business process, problem solving, and learning allows the usage of real scenarios, experiences, and resources between the systems. For such an integrated architecture and process scheme, DIN DOM as the core exchange format provides scenarios and related information. The above mentioned scenarios show how even a loose coupling of the systems can improve knowledge support for the workforce. However, the transfer of scenarios, situations, competencies, and adaptation functions requires semi-automatic adaptations. Next generation systems should provide automatic detection, adaptation, and contextualization functions.

Evaluation of the Model

The process of standardization in the German Standards Body (DIN e.V.) included several steps of evaluation. In the first stage, the requirements of different user groups were collected. As stated previously, several user groups were involved in this process, in total 65 participants from all educational areas. In parallel, existing approaches were analyzed and related to the requirements of the user groups. This resulted in the requirements and assumptions shown in the section describing the Educational Modeling Languages. The main goal of the process was then to evaluate whether the requirements of different user groups (as described in 4.1) were met and if the model is suitable for developing new integrative solutions. Therefore, the specification development process was done using several feedback loops. At each stage of specification development, structured feedback (requirement analysis and refinement, specification verification and validation, improvement suggestions) was collected in interviews and questionnaires. The results were discussed, leading to consensus. Therefore, the standardization process itself is a validation process. Additionally, prototypes were used in the participants' organizations, the experiences were shared and went into the specification process. Therefore, the model was carefully evaluated in several stages over a period of three years.

Secondly, we performed an evaluation in the following setting which was selected as a representative scenario for the use of DIN DOM to facilitate knowledge sharing within an organization. The prototyping setting was chosen to test an environment where a) business and learning processes can be connected, b) knowledge sharing is not facilitated yet, and c) the communication between different actors (of different perspectives) can be improved. This setting is suitable for evaluating the appropriateness of the specification for the technology-oriented view and to analyze the connection of business and learning processes. The organizational units involved were the software development and human resources/training departments of a large refinery. Within its software development department test scenarios are written for specific software, in our case the steering software for filling and shipping processes. The main connection between business and learning processes was the generation of training scenarios from corresponding test scenarios. This means that software testers and evaluators developed E-Learning scenarios directly from test cases. The specification was used as the technical exchange format for both scenarios. The category *Experience* was used to exchange experiences between different departments (specifically, software testing and human resources/training). After six months, expert interviews (N=10) were taken. The main conclusions were:

- The Didactical Object Model is useful for the exchange of scenarios and the general description of training cases. Specifically, DIN DOM was used to transfer cases from software testing to the developers of product training.
- The didactical object model is helpful to structure experience exchange. It might be useful to apply ontologies to the subject in order to improve communication between experts from different disciplines.
- Both perspectives found the structured exchange very helpful to improve communication. However, for the use of the exchange format, support was necessary to find a common terminology and create a common understanding.
- The exchange of experiences might not work in a different environment, e.g., when barriers and competition between departments or organizations occur.

The use of simple XML-editors to develop and edit the DIN DOM is not sufficient for all users. Graphical user interfaces were widely requested and recommended.

The main conclusion was that DIN DOM can be used to model complex scenarios (such as workplace oriented scenarios, generated from test scenarios). However, tools and applications are urgently needed to involve all users, not limiting the use to users with a high technological competence. The experience exchange was initiated and worked well in the environment which means that the use of the specification in connection with human-oriented knowledge management instruments can work as an enabler.

Two additional evaluation steps will follow the evaluation-process steps which have already been performed; in the German Standards Body and the above described experiment. The main goal of these additional evaluations is to demonstrate that the model can be efficiently used in various contexts, especially in the connection of knowledge management and learning processes, and to reach new target groups.

First of all, the model will be submitted to the standardization bodies, specifically to ISO/IEC JTC1 SC36. This next step will evaluate the suitability on the global level and will enhance the discussion on the specification. The main issue in this process is the relation of DIN DOM to existing specifications, specifically IMS Learning Design (as mentioned above as e.g., application profile, extension). This standardization process will include global experts to extend the requirements for use on a global level.

Besides, evaluation will be within the project Quality Initiative E-Learning in Germany (QED) (Pawlowski, 2005). In this project, innovative solutions for Small and Medium Enterprises (SMEs) are developed. Specifically, a repository for Mobile Learning Scenarios is developed to enable trainers and training developers in SMEs to design new training solutions. The main objective of this second part of further evaluation is to determine the suitability of DIN DOM to represent mobile scenarios, to develop workplace-oriented scenarios, and thus to relate knowledge management and learning systems in SMEs. The evaluation will be done over a period of 2 years to see the long-term effects of the use of mobile learning and knowledge management.

However, the first results from the evaluation-process; the standardization process and the prototypes were very promising. They have shown that the exchange of scenarios between departments and organizations can be facilitated. Nevertheless, support is still necessary to create a common understanding. For future development, this implies that tools should be developed easing the use of such a specification for different user groups.

Conclusion

Exchanging didactical expertise is a complex task. It must take into account concepts from various disciplines, such as Educational Modeling Languages and supporting Knowledge Management approaches. In this paper, we have shown the concepts of the DIN DOM which extends IMS LD by two main categories: *Context* and *Experience*.

By the use of these categories, the reuse of didactical scenarios can be improved by providing the technological base to enable structured knowledge sharing. Didactical scenarios can be filtered, chosen, and adapted based on the context. Additionally, experiences are collected for each didactical object. However, it is necessary to support the use of the specification with human-oriented knowledge management instruments. The experience and context extensions to the original IMS LD specification are the base for an efficient technology-oriented and human-oriented exchange of didactical expertise.

The first experiences with this concept led to promising results. However, in the near future a critical mass of scenarios needs to be available. Additionally, easy-to-use tools are urgently needed to involve more stakeholders within the community.

The DIN DOM will be forwarded to different standardization groups to improve current specifications, either as application profiles, new separate specifications for experiences and context, or as an extension to IMS LD. In parallel, repositories and tools need to be developed to reach a critical mass of users sharing scenarios, expertise, and knowledge.

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Learning Design based on Graphical Knowledge-Modelling

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ABSTRACT

This chapter states and explains that a Learning Design is the result of a knowledge engineering process where knowledge and competencies, learning design and delivery models are constructed in an integrated framework. We present a general graphical language and a knowledge editor that has been adapted to support the construction of learning designs compliant with the IMS-LD specification. We situate LD within our taxonomy of knowledge models as a multi-actor collaborative system. We move up one step in the abstraction scale, showing that the process of constructing learning designs can itself be viewed as a unit-of-learning (or a "unit-of-design"): designers can be seen as learning by constructing learning designs, individually, in teams and with staff support. This viewpoint enables us to discuss and compare various "design plays". Further, the issue of representing knowledge, cognitive skills and competencies is addressed. The association between these "content" models and learning design components can guide the construction of learning designs and help to classify them in repositories of LD templates.

Keywords

Learning design, Educational modelling, Knowledge-based systems, Graphic languages, Knowledge modelling, Competency-based learning design, IMS-LD, Learning design repositories.

Introduction

Building high quality learning designs is a very important and demanding task. It is also a difficult task that we started to address already a decade ago by progressively building an instructional engineering method (Paquette et al. 1994; 2005a; Paquette, 2003), a delivery system (Paquette et al., 2005b) and a graphical knowledge modelling editor (Paquette, 1996; 2002).

In this on-going work and for the present discussion, the point of view is taken that a Learning Design is the result of a knowledge engineering process, where knowledge and competencies, learning design and delivery models are constructed in an integrated framework.

In the next section of this article, a generic graphical modelling language is defined, MOT (Modelling using Object Types) which was developed as the backbone of our instructional design methodology. Our taxonomy of knowledge models will be presented and learning designs will be characterized according to this taxonomy as collaborative multi-actor process models.

The third section will present the MOT+LD editor, as a Specialized Graphical Modelling Tool for IMS Learning Designs, as well as some examples and a process to engineer learning designs. We advocate that this construction process can also be modelled as a multi-actor process model in order to analyze and improve learning design methodology.

The last section presents other types of MOT models which represent domain knowledge and competencies that can be used to plan, support staff roles and evaluate the quality of learning designs. Finally, we propose that the domain and competency models can provide a classification scheme for a library of learning design templates.

Graphical Knowledge Modelling

Graphical knowledge modelling is a way of representing knowledge structures or domains by linking concepts, procedures and principles in a way that describes the phenomena at hand. In the case of Learning Designs, the basic structures can be likened to a workflow model containing information on who does what, when and with what type of resources.

When designers start building a Learning Design, two basic questions arise: “Which knowledge must be acquired and what are the target competencies or educational objectives for that knowledge?” and “How should the activities and the environment be organized to best achieve knowledge and competency acquisition? To help designers solve these types of questions, we have developed a graphical knowledge modelling method and tools. In this section, we briefly present the basis for a modelling language to provide operational support to designers by discussing and explaining its goals, syntax and semantics as well as types of models and examples.

Goals of the MOT graphic language

It is often said that a picture is worth a thousand words. That is true of sketches, diagrams, and graphs used in various fields of knowledge. *Conceptual maps* are widely used in education to represent and clarify complex relationships between concepts to facilitate knowledge construction by the learners. *Flowcharts* are graphical representations of procedural knowledge or algorithms, composed of actions and decisions that trigger series of actions in a dynamic rather than static way. *Decision trees* constitute another form of representation used in various fields, particularly in decision-making expert systems, establishing influence or cause/effect relations between various factors. Building a decision tree is equivalent to building a series of rules which will constitute the knowledge base of the expert system.

In the last ten years, our main goal has been to generalize and consolidate various forms of graphical representations, which are useful for educational modelling, using an integrated graphical symbol vocabulary. In Paquette (1996; 2002; 2003), we have shown that different kinds of models can be modelled more precisely using the same graphical language (syntax and semantics) by utilizing typed objects (concept, procedures, principles) as well as typed links. With this set of primitive graphic symbols, it is possible to build very different graphic models, from simple taxonomies to ontologies, more or less complex learning designs, delivery process, decision systems, methods etc. Besides its generality, the MOT graphical representational language has been proven sufficiently simple and friendly to be used by persons with non-technical background in many different contexts through the years. Modelling facilitates thought organization and communication between humans about the knowledge as the graphic representation model evolves. As will be seen, it can be used both at a specialized domain knowledge level and at a meta-knowledge level, such as cognitive skills and competencies. Finally, the graphical MOT+ editor exports its models to different kinds of XML formats, including IMS-LD and OWL, for machine processing.

The benefits of graphical knowledge or cognitive modelling (Ausubel, 1968; Dansereau, 1978; Paquette, 2002) can be summarized as follows: it

- illustrates relationships among components of a complex phenomena
- makes evident the complexity of actors interactions
- facilitates the communication of the reality studied
- ensures the completeness of the studied phenomena
- helps scanning for a general idea because it minimizes use of text.

Syntax of the MOT Graphic Language

Concepts (or classes of objects), *procedures* (or classes of actions) and *principles* (or classes of statements, properties or rules) are the primitive objects of the MOT graphical language. Other primitive objects are instantiations of these three kinds of classes that correspond to single individuals. These individuals are respectively called *examples*, *traces* and *statements*.

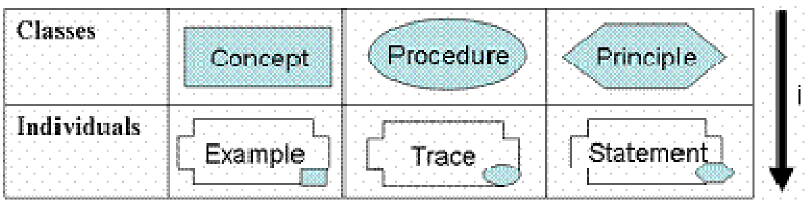

Figure 1. Types of knowledge units in MOT

MOT models are thus composed of up to six types of objects or knowledge units. The *object* type is represented by a geometrical figure as shown in figure 1, where each class or individual is represented by a name within the figure. Classes can be related to corresponding types of individuals by an instantiation (I) link.

Table 1 presents various possible semantic interpretations of these graphic symbols.

Table 1. Interpretation of various types of knowledge

Type	***Interpretations and Examples***
Concept	• Object classes: country, clothing, vehicles… • Types of documents: forms, booklets, images… • Tool categories: text editors, televisions… • Groups of people: doctors, Europeans… • Event classes: floods, conferences…
Procedure	• Generic operations: add up numbers, assemble an engine… • General tasks: complete a report, supervise production… • General activities: take an exam, teach a course… • Instructions: follow a recipe, assemble a device… • Scenarios: the unfolding of a film, of a meeting…
Principle	• Properties: the taxpayer has children, cars have four wheels … • Constraints: the task must be completed within 20 days … • Cause and effect relationships: if it rains more than 5 days, the harvest will be in jeopardy … • Laws: any metal sufficiently heated will stretch out … • Theories: all of the laws of the market economy… • Rules of decision: rules to select an investment … • Prescriptions: principles of instructional design principles … • Regulating agent or actor: the writer who composes a text …

The *relations* we use between objects are represented by links bearing a letter that specifies the type of relation. There are six basic types of relations or links that connect the various types of objects to form more complex models.

- The i*nstantiation link* (I), connects abstract knowledge (classes) to corresponding types of individuals
- The *composition link* (C) connects a class to other classes, either component attributes or constitutive parts of concepts, sub-procedures of procedures or component principles of more complex principles or set of principles; the C-link can also connect an individual to component individuals.
- The *specialization link* (S) connects two abstract knowledge objects of the same type, in which one is a sub-class of the other one; in other words, the second class is more generic or more abstract than the first one.
- The *precedence link* (P) connects two procedures or principles of which the first one must be completed or evaluated before the second starts; in a trace, it also connects individual actions of statements to other subsequent individual actions or statements.
- The *input-product link* (I/P) connects a concept and a procedure, from an input concept to the procedure (examples of the concept are possible inputs) or from a procedure towards an output or produced concept (examples of the concept are possible outputs of the procedure).
- The *regulation link* (R) connects a principle to another class; in the case of a concept, the principle defines the concept by properties to be satisfied (sometimes called "integrity constraints"), or it establishes a law or a relationship between two or several concepts (for example rules); the regulation link from a principle towards a procedure or another principle means that the principle controls the execution of the procedure or the selection of other principles, for example a rule-based system controlling the execution of a process from the outside.

Types of Models: Ontologies and Learning Design

These basic classes or individual objects can be combined into increasingly complex systems of structured knowledge. For example, it is possible to represent conceptual maps, flowcharts (iterative procedures) and decision trees, and also other types of models useful for educational modelling.

Figure 2 presents five main categories of MOT models which are subdivided into sub-types. (See Paquette 2002 for more details).

Of particular interest here is the class “processes and methods” within which learning design is included, and “laws and theories” composed of concepts that can be organized in specialized hierarchies or part-whole hierarchies, and principles defining their properties and relationships. Particular cases are ontology models describing knowledge domains and competencies.

In Paquette et al. (2005a) the relationship between both types of models is presented as the foundation of the MISA method, which will be discussed further.

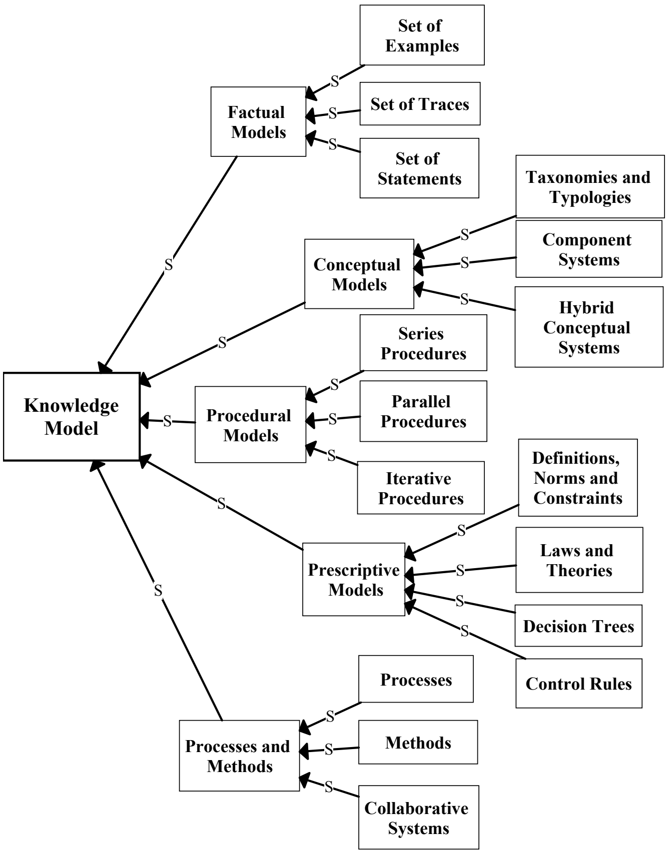

Figure 2 –Taxonomy of Knowledge Model Categories

Learning Designs as Collaborative Systems

The *“Processes and methods”* class in the knowledge models taxonomy, shown in figure 2, is a class that groups models mainly composed of procedures, where complex procedures are decomposed into simpler ones, each with their inputs and products. Three sub-categories can be discerned:

- In “*Processes*” the execution of procedures is achieved by simple decision principles; the flow of control is embedded within the procedures in an algorithmic way.
- In “*Methods*”, the execution of the procedures is controlled by a set of principles; these principles can be heuristic rules governing the flow of control from outside the procedures that compose the model.
- In “*Collaborative Systems*” the execution of procedures is controlled by collective/collaborative decision principles; the control is distributed between formal rules embedded and described within the model, and actors personified by human participants that apply control to the process based on evaluations made at run-time.

From these definitions, it is possible to characterize the innovation that learning design brings to educational modelling. SCORM-based scenarios for example are sometimes simple processes, and sometimes (very rarely in practice) methods where simple sequencing (IMS-SS, 2003) of activities is done by formal rules defined in the system.

IMS Learning Design, because it favours collaborative systems, adds a new dimension to simple sequencing systems. Activities are controlled by a combination of actors (making decisions at run-time) and formal rules:

simple on-completion rules in LD level A, more or less elaborated rule-based systems (conditions) in LD level B, and rule-based systems mixed with actor notification in LD level C. Notifications request actors to exercise some control on the learning process according to the activation of certain conditions.

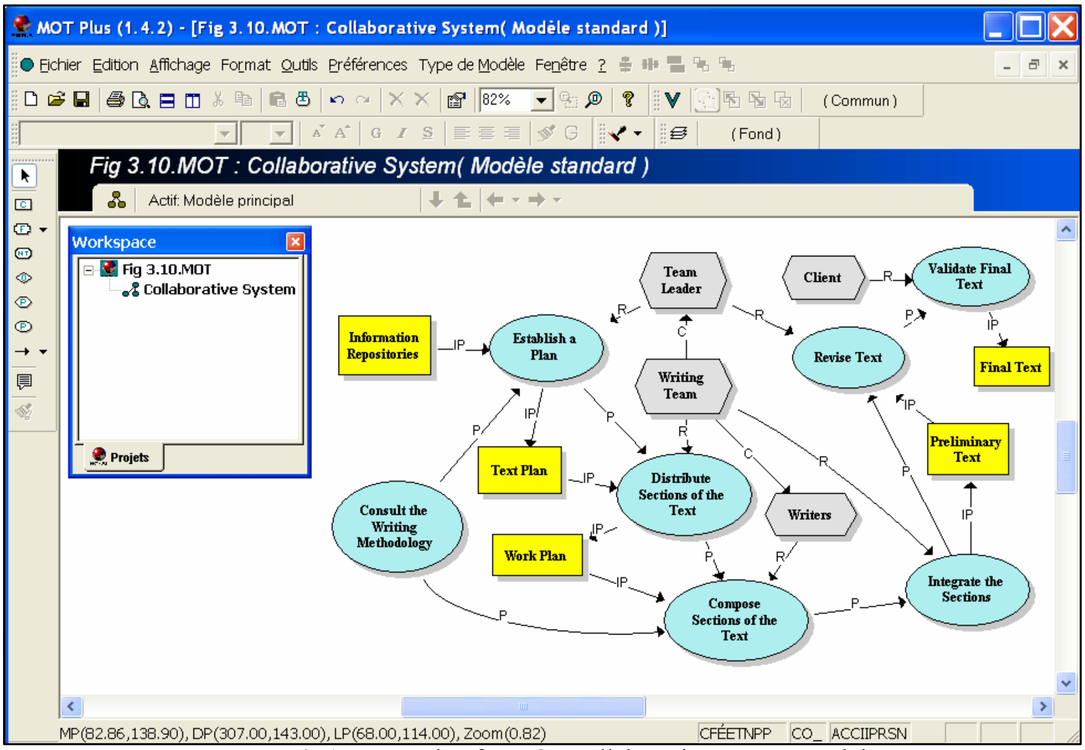

Figure 3. An example of a MOT collaborative system model

Figure 3 offers a MOT model of a collaborative system very similar to learning design where activities are represented as procedures (ovals), input and output resources as concepts (rectangles) and actors by principles or control objects (hexagons). “Modèle standard” means that the general MOTplus editor is used. This general modelling tool has served as the basis for the development of the MOT+LD editor, described in the next section.

MOT+LD: a Graphical Learning Design Editor

In this section, our graphical learning design editor MOT+LD is described. It is based on the same graphical language explained in the previous section. This development stems from MOT’s sophisticated and mature graphical capabilities that were already in place and ready to be adapted. Any knowledge object can be decomposed into a sub-model on any levels. Each object can be associated to OLE compliant files, enabling a concrete walk-through of a model. Moreover, a standard feature of the MOT+ model editor makes it possible to associate components from co-models, such as a domain knowledge model. This feature is also available in the LD version of the software.

Griffiths et al. (2005) survey of learning design tools includes other graphic editors, which shows the interest and adequacy of graphical modelling to express learning scenarios or learn flows. In the IMS-LD best practice documents (IMS-LD 2003), the UML modelling system includes activity diagrams and others that can be used to represent certain learning design concepts and activity flows, but not all. Although UML is now a standard in software engineering, and widely used, the different diagrams are not very well adapted to the task of building learning designs because it does not include the resources needed to carry out an activity, nor the outcomes. Another proposal is the LAMS software, which is not LD-compliant, and which simplifies the learning designer’s tasks by providing a drag and drop mechanism for assembling a limited set of learning design components (flows of activities and resources in the environment). We believe that this approach is interesting, but not powerful enough to support the whole LD specification. The advantage of MOT+ models is that they allow the illustration of all levels of the LD specification, including a simple Method model as well as the details of each act, including environments with its resources, the role-parts and the rules.

The MOT+LD graphical editor enables designers to fully describe the structure and concepts inherent in Level A unit-of-learning and to produce an instance of a standard LD XML schema. Work is on-going to extend the editor to levels B and C. In Griffiths et al. (2005), this approach is considered "significant, not only because it provides an example of a powerful and expressive high-level LD editor, but also because the structures of LD are mapped onto a graphical language which appears to be very remote from the specification". Our aim is to provide a way closer to instructional designer's needs for building Learning Designs, alleviating the designer from having to deal with XML, but at the same time automatically producing an IMS-LD conformant XML manifest file derived from the graphs.

MOT+LD Graphic Vocabulary

Basically, all the MOT objects and links applicable to LD models were used and interpreted with much of the same general semantics. Figure 4 shows the resulting equivalences and symbolism. Resources are represented by five kinds of concepts (rectangles), the LD method components (actions) are represented by seven kinds of procedures (ovals), whereas actors and rules are represented by five kinds of principles (hexagons). Individual objects are represented by clipped rectangles (called "facts" in MOT+) representing learning objectives and prerequisites, metadata, items, and four other types of objects needed to describe conference, send-mail and index-search services.

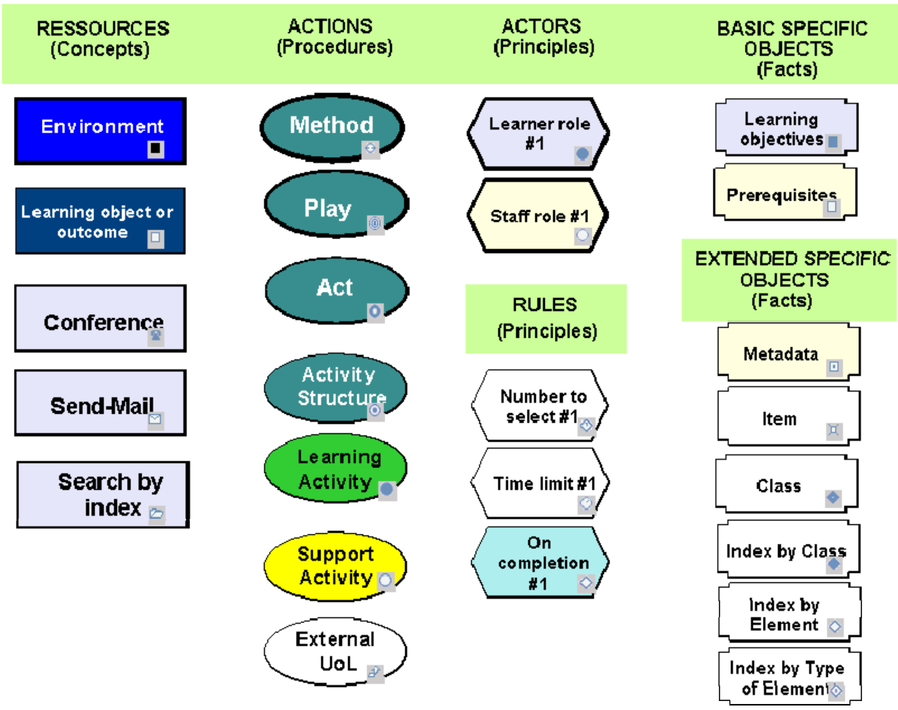

Figure 4 . MOT+LD basic vocabulary

The same basic links as in the general MOT language can be applied, however a number of new constraints on links between subtypes were added in order to comply to those specified in the IMS Information and Binding model and to produce a valid XML manifest file.

Figure 5 underlines the relative complexity of the LD information model (IMS-LD, 2003) but helps to understand it better. It shows a rather straightforward use of the composition link (C link). An environment is composed of other environments recursively or of other types of resources, such as learning objects, outcomes and/or services. Learner and staff roles, and also items can be organized in sets of component hierarchies. Methods are decomposed into plays, which are decomposed into acts, which are decomposed into role-parts, represented in our model by a role associated to an activity at any depth; finally terminal activity structures are decomposed into learning or support activities or a reference to an external unit of learning (UoL).

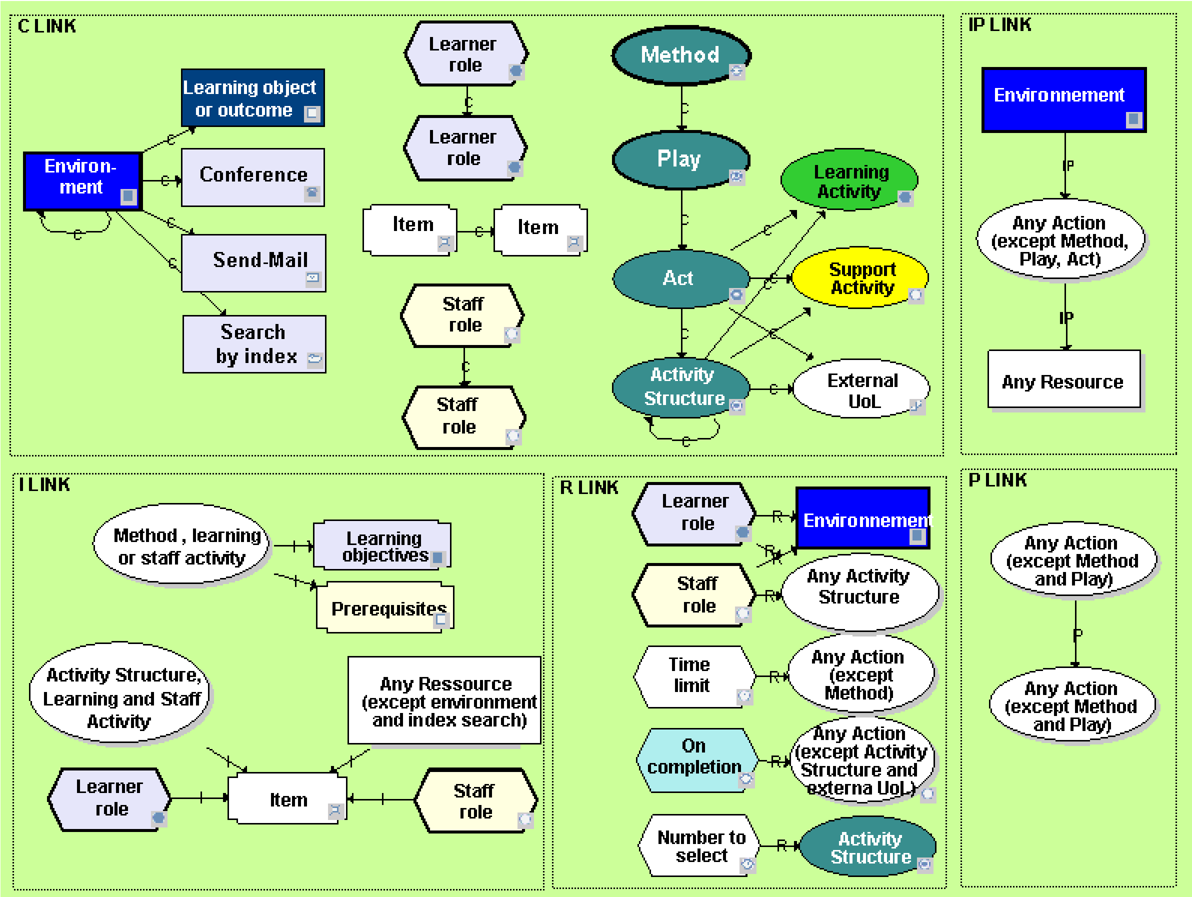

Figure 5. MOT+LD link constraints

The use of input/product (I/P-link) and precedence (P-link) links is clear and unambiguous. The precedence link is used between procedures only below the Play level, for example to show the order the acts are to be played. The I/P link is used only below the Act level, from an input resource to a procedure (LD Activity), that is to indicate resources in the environment of an activity, or conversely, from a procedure (LD Activity) to its resource outcome. This is more precisely put than the specification itself, since the LD XML file does not distinguish between input resources and outcomes, whereas the outcome is a necessary ingredient of a Learning Design from a designer's point of view.

The instantiation I-link associates learning objectives and prerequisites to a method or to learning activities. Activity structures, learning and support activities, learning and staff roles or resources (except environment and index search) can be associated to items pointing to a location where the physical file of the objects are found.
Finally, the regulation link (R-link) associates learner and staff roles to an environment or activity structures, learning or support activity, or it may associate a time limit to any action except the method. It is also used to associate a completion rule to an action except the activity structure and UoL. The number to select rule is R-linked to an activity structure when options are proposed.

Technically, to represent all IMS-LD concepts, subtypes of the original MOT+ object types as well as new graphical symbols with standardized labels (as shown in figures 4 and 5) were developed. The most difficult and time consuming part was to extend the native MOT XML schema and to parse it into a valid IMS-LD XML schema.

A post-validation mechanism was built into the parser informing the designer whether an IMS-LD rule has been violated and where to find it in the model. The number of possible violations was reduced while designing the model by limiting the choice of possible links between sub-types according to the constraints shown in figure 5. Finally, all the IMS-LD (IMS-LD, 2003) examples were modelled and tested, including the well-known and complex Versailles example (displayed in figure 6) by uploading them into the RELOAD editor (RELOAD, 2004), a form-based LD editor. This exercise resulted in very small discrepancies between our analysis of the specification and minor corrections were made to the MOT+LD editor to produce the present version. A version of the MOT+LD editor is available on the CICE Web site (www.cice.org) or on the Unfold Web site (http://www.unfold-project.net:8085/UNFOLD/).

Figure 6 shows the model of the Method in the Versailles example, which is composed of one Play containing 8 Acts. Act 6 was decomposed in a graph not shown in the figure, and composed of activity structures describing the negotiation day for each country. These models are all similar to the "France Negotiation Day" model presented in the second model in figure 6. Finally, each of the learning activities within this activity structure is structured the same way, as illustrated by the smaller model in the bottom right hand corner. This model presents the France-Serbia side-room discussion in an environment composed of a conference service and a discussion activity as well as their items pointing to corresponding resources.

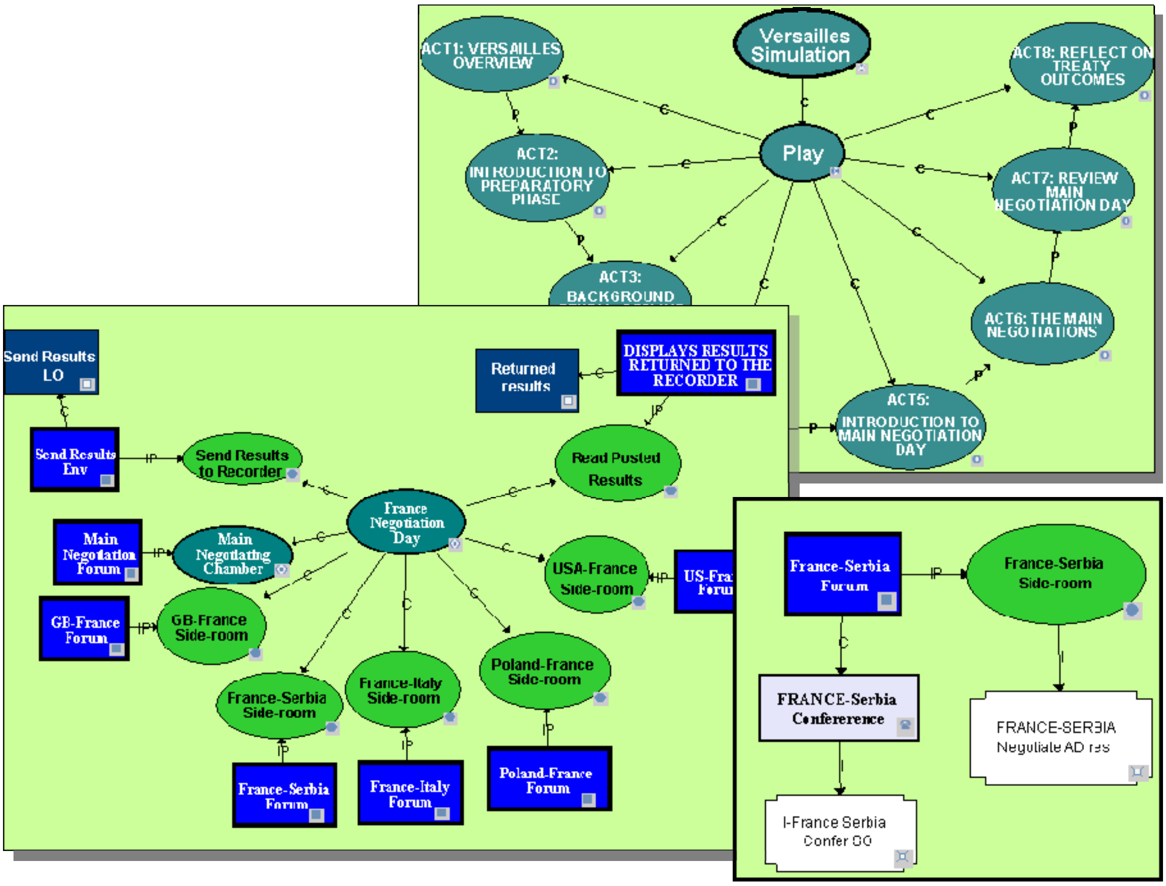

Figure 6. MOT+LD link constraints

LD Engineering Processes and Meta LD Models

A simple design process, based on the MISA Instructional Engineering Method as well as the IMSLD specification, is provided in the MOT+LD user's guide. Seven steps indicate the main tasks involved in engineering an IMSLD Unit of Learning : 1- Open an LD template, 2- Add prerequisites and learning objectives linked to the Method object to guide the engineering of the UoL method, 3- Specify actor roles and hierarchies, specifying minimum and maximum for each role, 4- Develop the instructional structure (Method, Plays, Acts and Role-parts) as defined by the LD Information Model, 5- Add items to resources, activities, roles, add appropriate metadata to learning objects and services; 6- Save the model as an LD Manifest and revise, if necessary, 7- Export the manifest to an LD Player.

Obviously, these are only main processes. They are insufficient to effectively guide the whole engineering process, but they summarize the fundamentals of engineering an LD Model. Many elements are missing. Prerequisites and Learning Objectives could be obtained by modelling the domain knowledge and associating it to target competencies. Also, the gap between entry and target competencies give designers clues on the scope of the UoL and its corresponding knowledge model. Finally, as discussed in the last section, target knowledge and competency statements help orient designers on what type of learning strategies and activity structures to select. It is well known that conceptual and procedural knowledge are not learnt in the same way, for example to acquire the competency to apply an administrative procedure is less demanding than acquiring the competency to build and adapt such procedures.

A couple of years ago, the MISA Instructional Engineering Method, its operations, products and principles were modelled using an early version of the MOT software. Presently, a new model of MISA using the MOT+LD software is being developed within the framework of the IMS-LD information model.

Figure 7 represents the MISA method as one of many possible engineering methods to create a "Unit-of-Learning". This MOT+LD model shows two plays, one for Web delivery and the other for classroom delivery. Many other plays are of course possible. In the Classroom play, only the first act is needed since the UoL will be delivered directly by the professor. In that case, only the steps 1-2-3-4 of the above engineering method are required.

In the Web delivery play, the designer (or the design team) will have to add two more acts besides the LD model composition. Act 2 is where the components are itemized to be assigned to concrete resources, activity assignments or participants, and also where services are described more precisely. Act 3 simply produces a validated LD XML file for delivery purposes.

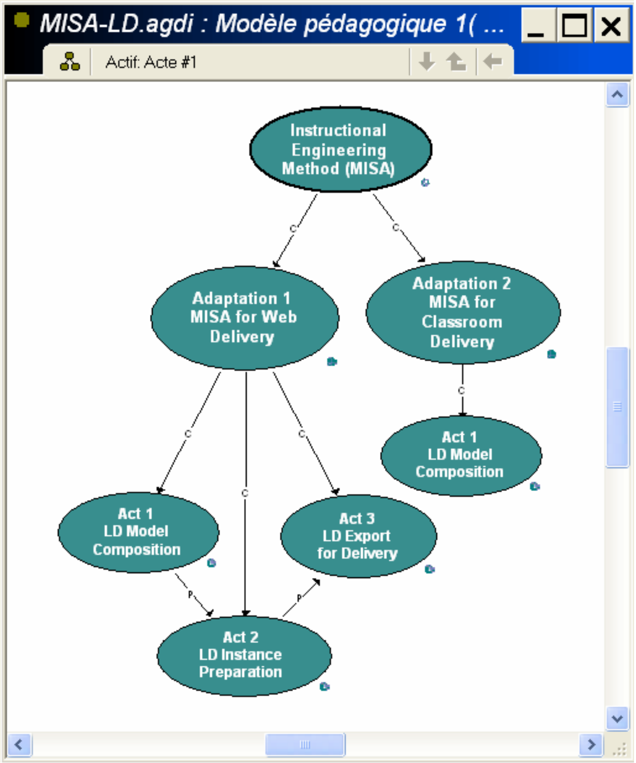

Figure 7. MISA as an LD (meta)-method

A general instructional engineering method like MISA can be adapted to many different situations. The preceding discussion opens the way to investigate a variety of ways to adapt MISA as an LD construction method described as alternate "design plays .

Figure 8 shows a partial model of Act 1, where the main Activity Structure is called "MISA for Web delivery" including the role-parts for the designers as learners and IMS-LD facilitator as staff. The flow shows the design team's preliminary analysis of training needs, target population, available resources, delivery and cost constraints, etc. followed by four processes, again modelled as activity structures, starting in parallel. These activity structures correspond to the design team's role-parts for each of the content expert, the instructional designer, the media designer and the delivery specialist as Learner Roles. In figure 8, the designer role-part is derived from the R-linked Instructional Designer Role (hexagon) to the Instructional Modelling Activity (oval). The other role-parts are derived in a similar manner, although not developed here.

The instructional modelling activity structure corresponds directly to the engineering of the learning design. This activity is supported by a Staff Role where an IMS-LD facilitator coaches designers using an IMS-LD guide and an LD forum included in a community-of-practice environment. Designers start by stating instructional orientation principles and proceed to develop the UoL using an environment composed of the MOT+LD editor, the PALOMA learning object manager (see Paloma LO Repository Manager http://www.cogigraph.com) and the RELOAD tool. Then knowledge units and competencies are associated to learning activities and to resources (using metadata).

Generic Skills and Learning Designs

The relationship between a learning design model and a knowledge and competency model is critical. In IMS-LD, prerequisites and learning objectives can be defined using the IMS-RDCEO specification (IMS-RDCEO, 2002). In Paquette & Rosca (2004) we have shown that using unstructured text to define competencies or learning objectives is not sufficient to help guide the learning design engineering. Furthermore, competencies should be linked to knowledge units in the learning domain, where both should be associated to actors, activities and resources at any level of the learning design. In this section, the notion of competency specification is elaborated by relating cognitive skills to knowledge, our taxonomy of cognitive skills is defined, and a way to represent them as procedural (meta-) knowledge models is explained. Further, we show how competency modelling can contribute to the guidance of the learning design engineering process.

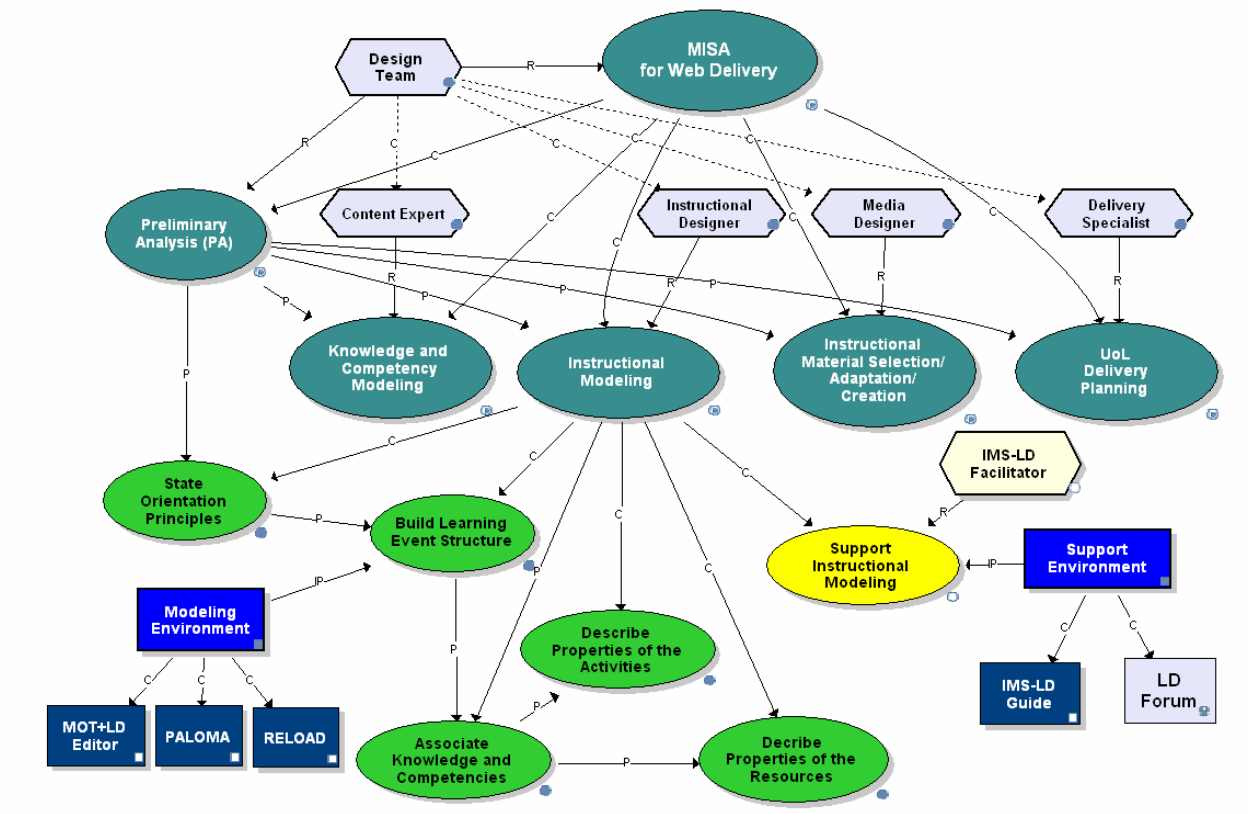

Figure 8. MISA for Web delivery Act 1 – Main activities

Competency: Cognitive Skills Applied to Knowledge

To say that a person knows something (prerequisite) or that a person must acquire some particular knowledge (learning objective) is not sufficient. What is needed is to specify a degree or a level of knowledge mastery. Thus, we define a *competency* as a statement that an "actor" has the ability to apply to a certain knowledge unit, a precise *cognitive skill*, with a specific degree of "performance" in a certain context.

We define a *cognitive skill*, as a generic intellectual, socio-affective or psycho-motor ability, such as to memorize, transpose, analyze, synthesize, evaluate, self-control and so on, which can be applied in different knowledge domains. If more precision is needed, a degree of *performance* can be added by specifying the situational context where the cognitive skill is to be applied: in familiar or new contexts, in a persistent or sporadic way, in simple or complex situations, etc.

Competencies state objectives to be reached in relation to some knowledge unit, or an actual state of the knowledge unit that someone possesses. They also identify the cognitive skill that must be applied by a learner or that can be developed or acquired through learning activities. Finally, by specifying a performance context, competency statements help designers build useful learning activities, environments and assessment tools to help learners and trainers test their knowledge and cognitive skill, which in turn is one way of ensuring some quality control of the learning design.

Possessing a cognitive skill means that a learner can solve a corresponding class of problems (Chandrasekaran, 1987; McDermott, 1988; Steel, 1990). For example, if a learner possesses a diagnostic or classification skill, it implies that this learner is able to solve some diagnostic or classification problems to a certain performance level prescribed by the context. Another view is to see cognitive skills as active procedural meta-knowledge (generic procedures) applied to knowledge (Pitrat, 1991; 1993). A third view considers the association between cognitive skills and application knowledge as objects to be learned together, such as educational objectives principles and statements (Bloom, 1975; Krathwohl et al., 1964; Reigeluth, 1983; Martin & Briggs, 1986). Integrating all three viewpoints will enable us to provide a cognitive skill taxonomy that might prove useful in producing effective and efficient learning designs by identifying the gap between prerequisites (entry competencies) and learning objectives (target competencies).

Table 2. Taxonomies of Cognitive Skills

Cognitive Skills Taxonomy Levels			**Active meta-knowledge (Pitrat)**	**Generic problems (KADS)**	**Cognitive objectives (Bloom)**	**Skills cycle (Romiszowski)**
1	**2**	**3**				
Receive	**1. Acknowledge**					Attention
	2. Integrate	**2.1 Identify** **2.2 Memorize**			Memorize	Perceptual acuteness and discrimination
Reproduce	**3. Instantiate / Specify**	**3.1 Illustrate** **3.2 Discriminate** **3.3 Explain**	Knowledge Search and Storage		Understand	Interpretation
	4. Transpose/ Translate					Procedure Recall Schema Recall
	5. Apply	**5.1 Use** **5.2 Simulate**	Knowledge Use, Expression		Apply	
Create	**6. Analyze**	**6.1 Deduce** **6.2 Classify** **6.3 Predict** **6.4 Diagnose**	Knowledge Discovery	Prediction, Supervision, Classification, Diagnosis	Analyze	Analysis
	7. Repair			Repair		Synthesis
	8. Synthesize	**8.1 Induce** **8.2 Plan** **8.3 Model/ Construct**		Planning, Design, Modelling	Synthesize	
Re-invest	**9. Evaluate**		Knowledge Acquisition		Evaluate	Evaluation
	10. Self-manage	**10.1 Influence** **10.2 Self-control**				Initiation, Continuation, Control

A Skill Taxonomy

Table 2 presents an overview of the proposed the skills taxonomy. This taxonomy combines and adapts an artificial intelligence taxonomy (Pitrat, 1990), a software engineering taxonomy (Breuker & Van de Velde, 1994; Schreiber et al., 1993) and two educational taxonomies (Bloom, 1975; Romiszowski, 1981). Although the terms are not in direct correspondence, table 2 distributes them onto ten levels that lay the foundations for our taxonomy (Paquette, 1999; 2003)

In this taxonomy, cognitive skills can be viewed according to three perspectives: as a generic problem solving process, as procedural meta-knowledge acting on knowledge or as a learning objective related to a knowledge processing task. Contrary to the traditional view on learning objectives, skills are here viewed as knowledge objects that can be described, analyzed and evaluated, by themselves or in relation to various knowledge domains.

The taxonomy shown in the left part of table 2 portrays three levels, from left to right, from the generic to the specific term. It could be expanded to more levels for additional precision. The first two levels are ordered from simple to complex. A detailed discussion of the validity of this ordering can be found in (Paquette 2002) together with precise definitions and examples of each skill.

Representation of a Cognitive Skill

Every cognitive skill in the taxonomy can be represented as a MOT process model by a main procedure in the meta-knowledge domain, which is the domain that categorizes knowledge and describes processes and principles to transform and acquire knowledge. The main procedure is broken down into sub-procedures, to as many levels as needed, until terminal procedures are found that do not need further decomposition. For each procedure, there is also a description of input or product concepts that feed them or are generated by them, as well as principles that regulate the transfer of control between the generic procedures. Cognitive skills or processes are thus structured sets of generic cognitive actions that can be instantiated to different knowledge domains called application domains.

In table 3, the "5.2-Simulate a process" skill, a sub-class of the level "5-Apply skill", is compared to the level "8.3-Construct a process" skill, which is a sub-class of the "8-Synthesize" skill in the taxonomy.

Table 3. Comparison of two generic skills

Skill	Input	Product	Process Flow
Simulate a process	A *process*, its procedures, inputs, products and control principles.	A *trace* of the procedure : set of facts obtained through the application of the procedures in a particular case	- Choose input resources objects (data) - Select the first procedure to execute - Execute it and produce a first result - Select the next procedure and execute it - Use the control principles to control the flow of execution
Construct a process	Definition constraints such as relations between inputs and products of the process and/or required steps in the process.	A description of the process: its inputs, products, sub-procedures with their input and output, and the process control principles.	- Assign a name to the procedure to be constructed - Relate this main procedure to a specific input and product resource, respecting the definition constraints - Decompose the procedure, respecting the definition constraints - Continue to a point where well understood small procedures are defined.

From the descriptions of these two generic skills, we can easily see that a learning design aiming at the acquisition of procedural knowledge such as "Information search on the Internet" will be very different if the goal (the learning objective) is to simulate that process or to construct it. In the first case, a number of demonstrations and exercises of the process will probably be sufficient, while in the second case, a project-based scenario where learners are engaged in a more complex problem-solving activity is a better suited learning strategy. The description of both processes is however just a summary example to illustrate the potential use of competency statements.

From Cognitive Skill Models to Activity Structures

The cognitive skills are processes, which are easily represented as MOT models. The MOT+ graph on the left side in figure 9 entitled "Meta-knowledge Model" provides a more precise definition of the "Simulate a process" skill. This cognitive skill is described by its main procedures with its input (the process to simulate) and its product (a trace of the process). These main procedures are decomposed into sub-procedures, each being associated with less complex cognitive skills that provide intermediate products, which are reused by other sub-procedures until the process is completed. The resulting trace can be produced by collecting the individual products from each exercise. On the graph, four groups of principles are added to constrain concepts and/or control procedures in the learn flow. Note that this model is totally generic, applicable to any specific knowledge domain, such as Internet processes, manufacturing processes, or others.

Figure 9 provides an example of how to build an activity structure based on such a cognitive skill model. In this activity structure, learners will simulate the process "Search information on the Internet" performing learning activities similar to the sub-procedures of the "simulate a process" skill. To build the activity structure shown on the right part of the figure labelled "Learning Scenario", a graph similar to the generic process is modelled, however, taking a "learning activity" viewpoint. The specific domain vocabulary is used, and the five activities are formulated in an "assignment style" format. As in the cognitive skill model, the activity structure starts with a description of the process to simulate and ends by producing a trace report of the simulation.

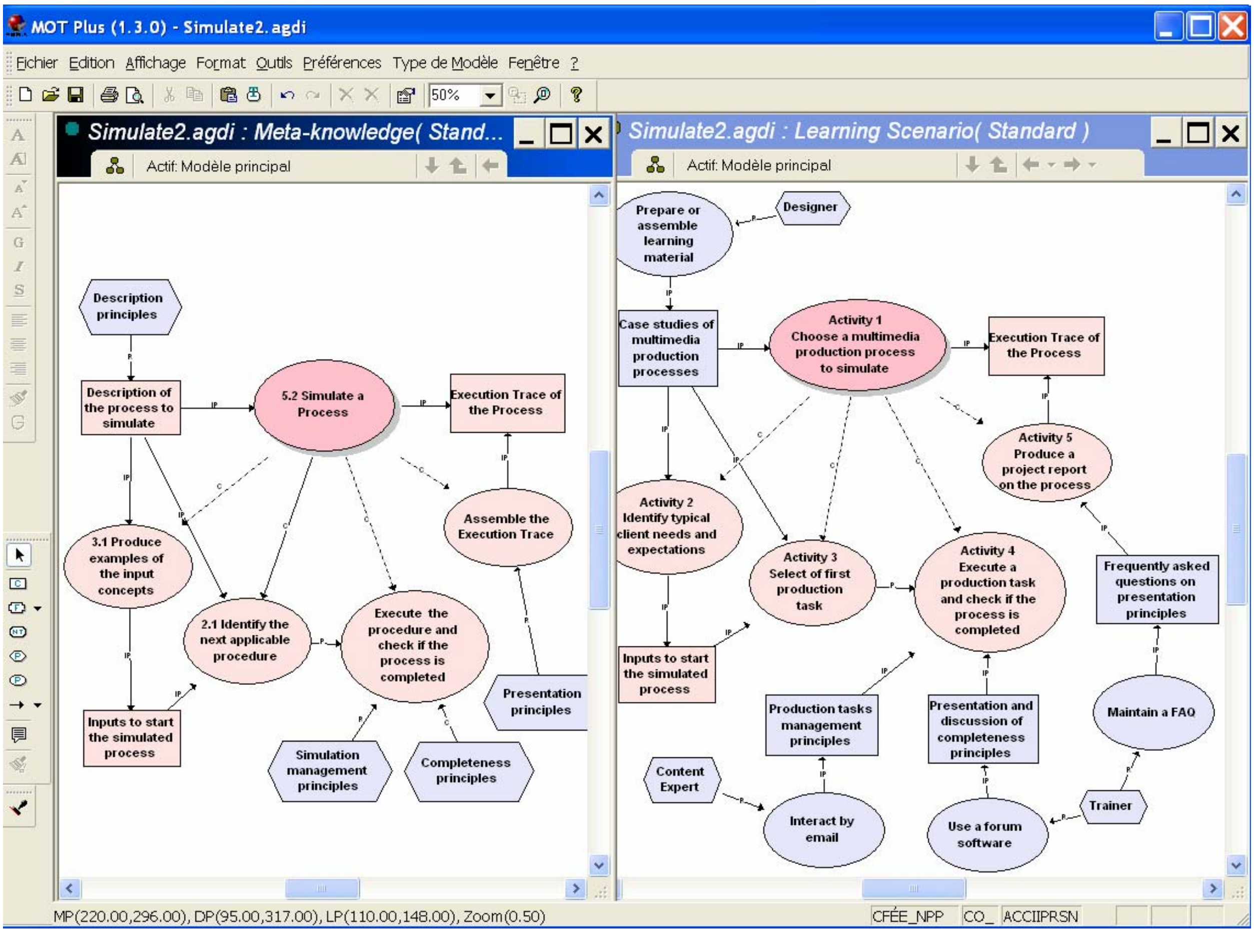

Figure 9. A learning scenario model simulating the "Search the Internet" process

Of course the learning design is not yet complete. For example, resources that help learners achieve their tasks can be added, such as a tutorial on the request structure or on a final report form. Also, we might specify some collaborative assignments and maybe a description of the evaluation principles that will be used to assess the learner's work. All these additions should be guided by the skill model's set of principles in order to ensure instructional quality. For example the "completeness principles" can become a check-list for the learner, or a guide for a trainer to help learners execute the simulation in its entirety.

But the important thing here is that the generic process becomes the founding principle for the learner's assignments. In that way, it is possible to make sure that the learner exercises at the right skill level, in this case "simulating a process", while working on the specific knowledge domain, thus building specific domain knowledge and meta-knowledge at the same time.

Metadata for Learning Design Repositories

Another use of the skill taxonomy is to help identify important metadata for learning design repositories. Recently, while working on documents to support the use of Educational Modelling Languages and the IMS Learning Design specification (IMS-LD, 2003), it was stated that "To support reusability of good learning designs, it is essential that libraries of learning designs can be made available as learning objects in one or more repositories" (Paquette et al., 2005). In Koper (2005), similar preoccupations are expressed and discussed.

We propose that learning object repositories under construction in different countries should distinguish between "content object", "tool objects" and "process objects", the latter including generic and specific learning designs (or scenarios). If a growing library of these learning designs is available, then reuse by adaptation to particular knowledge domains can increase. New learning design templates could be built by abstracting generic processes from a large body of existing scenarios, situating the resulting abstraction in the framework of a generic skills taxonomy.

The preceding discussion opens a door to organize repositories of generic learning design templates related to competencies organized according to a skill taxonomy which can provide a way to classify learning designs or scenarios by their association to generic graphic knowledge-based models. In the beginning of the development of our Instructional Engineering methodology, we first developed a set of such templates that have been used to start the construction of learning scenarios in different domains, further enhanced with a small advisory system assisting the designer in selecting proper scenarios in different situations (Paquette et al., 1994). In the MISA documentation, later on, and in field applications carried out since, we have collected a large set of designs that need to be systematically organized as a kind of learning scenario repository or handbook. A more comprehensive collection is being created on the corpus of distance learning courses at Télé-université.

These learning design templates can be organized as a hierarchy indexed by the main cognitive skill they exercise and other metadata can be added to further identify the type of knowledge (concept, procedure, principle, facts) or knowledge model involved in the LD template. For example, it is quite different to synthesize or construct a taxonomy, or a process, or a decision tree thus demanding clarifications explaining the performance context of the LD template.

Conclusion

The systematic interpretation of competencies using the cognitive skills taxonomy creates a bridge between competency profiles and instructional engineering in many ways. For each main knowledge unit, the gap between the entry or actual competency and the target competency of the learner can guide the construction of knowledge models; if the gap is large, for example starting at a simple memorizing skill targeting an evaluation skill, then the knowledge model will be quite complex, more so then if the goal is just to increase the performance level within an evaluation skill.

As discussed, target competencies and their associated cognitive skill process model provide a solid foundation to engineer effective and efficient learning scenarios ensuring some type of quality control as well as serving as criteria for classifying learning design templates. Competency models also make it possible to create activities for other actors in the learning design aiming to improve coordination between roles and to offer appropriately adapted resources in each case.

In this paper, we have advanced a new strategy, competency based design based on a knowledge model, describing a design process that facilitates designer's tasks to create learning designs which are multi-actor learning processes. An instructional engineering method is itself a multi-actor process used to engineer other multi-actor processes for learners and staff. We believe this novel use of LD can shed light on alternative methodologies that will assist in implementing the IMS-LD specification more easily and with a solid instructional design foundation.

Learning design based on graphical knowledge modelling is the basis of all the discussion carried out here. It helps situate the components and the levels of knowledge involved in a more precise and transparent way. Our goal is now aimed at providing user-friendly and powerful tools to educators and designers to increase the production of higher quality learning designs.

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Panning for Gold: Designing Pedagogically-inspired Learning Nuggets

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ABSTRACT

Tools to support teachers and learning technologists in the creation of effective learning designs are currently in their infancy. This paper describes a metadata model, devised to assist in the conception and design of new learning activities, that has been developed, used and evaluated over a period of three years. The online tool that embodies this model was not originally intended to produce runtime executable code such as IMS-LD, but rather focussed on assisting teachers in the thought processes involved in selecting appropriate methods, tools, student activities and assessments to suit the required learning objectives. Subsequently, we have modified the RELOAD editor such that the output from our tool can be translated into IMS-LD. The contribution of this paper is the comparison of our data model with that of IMS-LD, and the analysis of how each can inform the other.

Keywords

DialogPLUS, Learning Design, IMS, Learning Activities, Nugget Model

Introduction

There has been mounting interest over recent years in mechanisms for facilitating the uptake, repurposing and effective use of existing digital resources to support learning and teaching in higher education (Littlejohn, 2003). Indeed, teachers are increasingly expected to create or adapt online learning activities, with or without specialist technical support. Potentially interesting resources, available from a range of in-house or external sources, can be used to enrich learning environments and student experiences. However, finding, or creating, suitable materials and embedding them in well designed-learning activities can be both challenging and time consuming.

The work reported here has been undertaken during the DialogPLUS project, under the auspices of the JISC/NSF funded 'Digital Libraries in the Classroom' programme. For DialogPLUS, teaching colleagues in Geography departments in two UK and two US universities (Southampton, Leeds, Penn State, UC Santa Barbara) are creating and sharing online learning activities that draw on a wide range of available resources. The academics involved have varying experience of using digital media within their current teaching practice. This paper presents the model we have developed to support them in the process of creating pedagogically-informed learning activities. It uses underlying taxonomies of sound learning and teaching approaches as a basis for both guiding, and subsequently describing, effective designs.

The model is presented to users via an online editor which supports and guides them in the specification of all the elements of a learning activity, including intended outcomes, related tasks, embedded resources and appropriate tools. The explicit purpose of this editor is to assist teachers in designing successful learning activities, both for their own use and in a way that facilitates sharing and adaptation. It thus encourages practitioners to emulate and reuse examples of established good practice.

During the three years of designing, developing, implementing and testing our model and online editor, we have monitored and become increasingly involved with the wider world of learning design and metadata standards. Perhaps most importantly, we have examined our approach relative to the IMS-LD specification. The analysis presented here compares and contrasts our model with IMS-LD, and proceeds to demonstrate how the two models are complementary. Most recently, we have been able to take a teacher-created learning activity described in our format and convert it automatically into an IMS-LD manifest. This offers the exciting possibility of a user friendly front end to existing or emerging tools that create machine independent, runnable learning activities. The paper concludes with reflections on how this work informs both the design of our own model and that of IMS-LD.

Learning Nuggets

At the heart of our model is the notion of a learning nugget. This term was adopted early in the project, at a time when there was heated debate in the learning technology community about what constituted a 'learning object' (Polsani, 2003). Rather than impose any particular view or definition, when we engaged at our early meetings with the Geography teachers we allowed their vocabulary and definitions to emerge. They proposed the idea of a 'nugget' to represent stand-alone learning activities that would vary in size and scope. It was endorsed by team members from both countries and all three disciplines, Geography, Education and Computer Science.

Nuggets are primarily comprised of tasks that learners will undertake in a particular *context* in order to attain specific *learning outcomes*. Contextual elements include subject area, level of difficulty, prerequisite skills or knowledge, and the environment within which the activity takes place. Declared aims and learning outcomes are addressed by a sequence of tasks, each of which may involve particular techniques, various roles and interactions, plus access to specified resources and associated tools. A task will take a prescribed length of time and may, or may not be assessed. Nuggets are, or should be, designed with a particular approach to learning and teaching in mind (Conole & Fill, 2005). Our editor therefore prompts the user to specify or select an appropriate theoretical approach. This enables appropriate guidance to be given as the details of a nugget are fleshed out and should be helpful to those who subsequently discover and seek to re-use or re-purpose them.

Some of the innovative nuggets developed over the last three years have enhanced existing courses, whilst others have resulted in the creation of completely new courses. Examples of digital media embedded in the nuggets are interactive maps, Flash objects, census and environmental databases and modelling applications. Nuggets may also contain links to websites, online text, images, audio and video clips. Many incorporate formative or summative computer-based assessments, such as quizzes, drag and drop exercises, submission of written answers or the results of data modelling. Facilities for student reflection and communications with other students and teachers are often included, for example learning diaries, email and discussion boards.

In seeking to share nuggets, valuable lessons have been learned about repurposing them for different learning outcomes, institutional and technical contexts. For example, a nugget that fosters student understanding of academic integrity began life in one of the US universities and has been taken up enthusiastically by the two UK partners. Repurposing involved much more than technically enabling the nugget to run in different VLEs. Institutional documents had to be replaced with appropriate local ones, quiz questions framed differently, and feedback rewritten to serve the needs of specific student groups. In another instance, census information about Birmingham, England was replaced with that for Birmingham, Alabama within a nugget shared by two of the partners. It is manifestly apparent that teachers will enthusiastically adopt a good design but they usually want/need to swap the original content for their own.

Nugget Metadata

Based on our work with the teachers, plus observation and evaluation of student learning, a metadata model that facilitates this approach to re-use was developed and incorporated into an online editor for nugget designers. The metadata elements are pedagogically orientated, with the intention that these descriptive fields could eventually facilitate searching for and retrieval of, nuggets stored in a digital library or other online repository. They also enable the nugget structure to be maintained whilst content is substituted.

The sequence of tasks within a nugget has proved a somewhat controversial aspect of our model. In designing a learning activity a teacher usually has a specific sequence in mind but, especially in an online learning environment, learners will not necessarily follow it. Indeed, project evaluators have noted several instances of student aversion to explicitly restrictive navigation. Our approach, therefore, is to describe in the metadata the teacher's proposed sequence but to aim for an instantiation of the nugget that does not restrict a learner's access to the resources.

Figure 1 shows how we have modelled the entities described above, thereby defining a collection of objects and associated metadata.

At the root of Figure 1 is the Learning Activity object, described with metadata such as name, difficulty, subject, pre-requisites, approach to learning and teaching and environment. A '*(t)*' next to a metadata field on the diagram indicates the value is selected from our pre-defined, but extensible taxonomy for that element. As the diagram demonstrates, a Learning Activity addresses a set of Aims with ancillary Learning Outcomes. Each Aim object has a textual description. Each Learning Outcome is of a defined Type and contains a set of Tasks which will be presented in the order specified in the Sequence field.

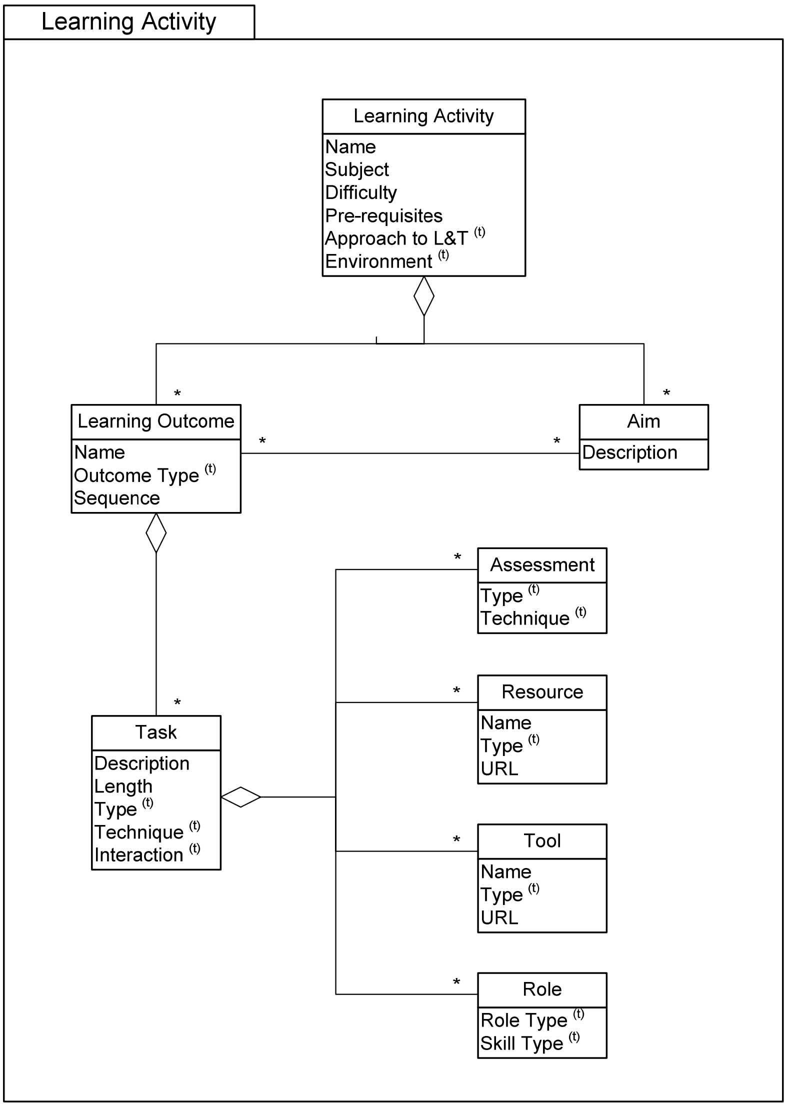

Figure 1: Conceptual UML Model of the Learning Activity Nugget Structure

Each Task is described by metadata covering Type, Technique, Interaction and Length of Time to complete. Further, to undertake a task, learners may need specific tools and resources. For example, if the first task is to read some introductory material, the tool in this instance would be the text viewer (MS Word, a web browser, Adobe Acrobat reader, etc.) while the resource would be the web page or text file the learner reads. The type of interaction for the task (one-to-one, one-to-many etc.) is selected from our taxonomy. As some tasks may be assessed, an assessment component can be attached to indicate what Type of summative, formative or diagnostic method is involved and the Technique used (multiple choice questionnaire, essay, exercise etc.). The final element in a task describes the associated Roles and Skill.

Together a sequence of Tasks, each with its own Tools, Resources, Roles and Assessments, comprise a Learning Outcome and these Outcomes help achieve one or more Aims. Aims and Outcomes make up a single Learning Activity.

The Wider Context

The increasing availability and use of online, digital resources to support teaching and learning is stimulating a convergence between the fields of learning design and learning object technologies. Indeed, in some quarters, the reusability debate has moved on from how to label digital objects using metadata so that other people, or systems, can find and use them, to how to describe "a whole learning experience" so that it can be "tweaked" for use elsewhere (Kraan, 2003).

This is consonant with the approach we had already adopted, so in our development of the nugget model, we have been able to draw on the growing body of work on standards for describing the various aspects of e-learning in international educational, governmental and commercial systems. These include the early days of SCORM, the evolving Learning Object Metadata (LOM) standards, IMS Learning Design and the many and various spin-offs.

The work in e-learning has its roots back in the early intelligent tutoring systems that arose from work spun out of the old AI research communities. During the 1980's these researchers focussed on representing the student's knowledge in explicit user models, and attempted to adapt the presentation of materials to this knowledge. In these early systems the instructional material and sequencing rules were generally locked into the specific system and not easily transferable. It wasn't until the late 1990's that work started on defining open standards to describe learning materials.

The Sharable Content Object Reference Model (SCORM) defines a Web-based model for combining learning objects and executing them within a run-time environment. ADL, the US initiative behind SCORM, was tasked with providing "access to the highest quality education and training, tailored to individual needs, delivered cost-effectively anywhere and anytime" (Dodds, 2005). To this end, SCORM has at its core, an inbuilt sequencing engine based on the earlier Simple Sequencing specification. Simple Sequencing (SS) is an IMS specification which defines a language to express an order or path through a collection of learning activities. The inclusion of SS within SCORM enforces a primarily didactic model of learning, and although pre-defined rules, branches and decisions can be made within the sequenced components, there is a lack of user model which limits the amount of personal adaptability that a SCORM lesson can provide on its own (Abdullah & Davis, 2005).

At the same time as SCORM was being developed in America, a group at the Open University of the Netherlands (OUNL) were also designing a model for describing learning units. Basing their model on wide ranging surveys of what other pedagogical experts and practitioners have been doing over the past century, Learning Design (LD) was created as a means of specifying the operation and delivery of educational material. LD was originally developed under the title Educational Modelling Language (EML) before being adopted by the IMS working group (Olivier & Tattersall, 2005). LD aims to provide a rich, varied and flexible language for building structured learning units that tries not to restrict pedagogical approaches, although it could be argued that it does take a more instructional design-orientated approach (Downes, 2003).

A learning 'unit' in this context can be anything from an atomic Learning Object to a module or course. Indeed IMS-LD is aimed at functioning at the level above that of LOM, and can be used in conjunction with the standard by referencing LOM objects when referring to environments. The specification defines a collection of reusable components which can be broken down or aggregated to form new learning units. LD uses a top level 'Components' object which contains all the Roles, Activities and Environments in a learning design. To bring these components together in a sequence, LD uses the analogy of a theatrical production with Methods consisting of Plays, and Plays consisting of Acts. The Acts specify the learning activities which are undertaken by a single role by referencing the Role and Activities objects from within the Components hierarchy.

Because a LD specification for a learning unit is designed to be independent of any delivery environment, services that are to be used by the learner (for example, an email, conference or announcement service) can be specified generically and subsequently resolved at run-time when required.

While these features are all to be found in IMS-LD level A, further levels (B and C) within the LD specification allow for more complex designs with personalisation based on user preferences, adaptability of learning material, dynamic (conditional) work flows through learning materials, role-play and event-driven simulations.

In recent months, editors have started to appear that allow designers to create a LD from scratch and attach metadata and resources to the unit. It can then be packaged into a single file to form a complete self-contained learning unit which can be imported into any 'IMS LD compatible' learning environment for presentation to users. Editors currently fall into two categories; specification editors such as RELOAD (Reload, 2005) and CopperAuthor (CopperAuthor, 2005) which provide a forms-based means of inputting the metadata for learning design with little or no guidance to support the user, and higher-level editors such as ASK (Sampson et al., 2005) and MOT Plus (Paquette et al., 2005) which provide a graphical medium in which designers can plan out the structure of learning units visually but still need the services of a form-based editor to finalise the production of the learning design. The next generation of graphical learning design applications aspires to eliminate forms entirely. An early example, the Learning Activity Management System (LAMS), uses a drag-and drop interface (Dalziel, 2003). This was inspired by learning design but, at the time of writing, does not support the IMS-LD standard.

To aid the adoption of IMS-LD, the OUNL have focussed their efforts on providing a free and open sourced set of middleware components that form a runtime environment for playing out IMS-LD designs, called CopperCore (OSTG, 2005). The idea is to provide developers of Virtual Learning Environments with an engine to manage the basic business logic of learning design execution. This business logic covers tasks such as learner synchronisation, constraint checking and learning unit personalisation for all levels of Learning Design (A, B and C).

The CopperCore system provides the missing link between development and execution for units of learning that have been modelled in LD with tools such as RELOAD. The adoption of LD is currently in its infancy and unlikely to become mainstream until existing VLEs support the import and execution of LD units with tools such as those provided by CopperCore.

One concern that may deter widespread uptake of the standards is that LD is too technical, and possibly too prescriptive, for creative teachers who have imaginative ideas but are unable to express them within the specification. What might be termed the 'SCORM effect' places emphasis on CBT-type, single-user, instructional designs. This has led us to reflect on how people think about constructing their learning designs, and specifically to consider how to merge our flexible and pedagogically sound approach to supporting nugget design with IMS-LD. While working on this aspect, we have become aware of others taking different approaches to resolving similar challenges with respect to teacher involvement. Broadly, these draw on exemplars of good practice or suggest particular models of teaching and learning processes to define patterns or templates that teachers can rework. Critical comparison of these schemes and our own is beyond the scope of this paper but interested readers are referred to Griffiths & Blat (2005).

In the next section we comment on the similarities and differences between our model and IMS-LD.

Comparing the Nugget Model with IMS-LD

While a large effort has been invested by bodies such as the IMS, ADL, LTSN and OUNL into defining standards for both learning object metadata and pedagogical structuring of materials (e.g. Simple Sequencing or IMS-LD), the initial aims and requirements for supporting our nugget design required a different approach. However it has been interesting to observe that the resulting learning activity model we produced has much in common with the IMS-LD specification.

We chose our own design metadata for a number of reasons. The collaborative standards efforts described earlier have provided a highly structured set of fields that can be machine processed. While this approach is essential if learning objects are to be automatically indexed in repositories and then searched and retrieved automatically via components such as software agents or learning environments, our objectives were slightly different. Our aim is to provide a set of metadata fields that would be most appropriate to teachers to understand and use when describing and searching for other nugget objects. In this respect the useful flexibility and expressive nature of IMS-LD is less important. This means the fields and data in our model have been chosen to represent a middle ground between being machine processable and being easily understood by the authors themselves.

The second consideration in choosing our own set of metadata tags was the desire for brevity. It is acknowledged that the standardisation effort aims to produce languages that are flexible enough to be used in a wide range of situations and this has led to large feature-rich models. Nevertheless, there is a general consensus that getting users to enter any sort of descriptive data is difficult; especially when the benefit of such work is not immediately obvious to users (Currier et al, 2004; Cardinaels, Meire & Duval, 2004). Adopting an external specification brings the added difficulty of being forced to use alien terminology that might deter teachers. In order to reduce the obstacles towards the adoption of our model we have chosen a reduced number of metadata items using terms and structures that are familiar to our specific users. However, as our aims for the model do extend beyond the small user group, the metadata have been chosen to be subject-neutral. It is intended that these fields will be descriptive enough for our requirements while also being useful to teachers outside our initial domain of Geography.

The decision to continue with our model also acknowledges that IMS-LD was developed with different set of objectives in mind. Our nugget specification represents, at a high, abstract level, the description of a learning unit with metadata that is primarily human understandable. This is in contrast to IMS-LD which, as an interoperability specification, is intended for machine use and in addition the editors currently developed for it are intended to be used by specialised learning designers whose role differs from that of the content providers (Olivier & Tattersall, 2005).

However, in spite of these differences in the approaches adopted, the resulting models have much in common. While their internal structures and how they organise learning activities differ, they can both be used to define the same units of learning. LD defines elements in separate groups (e.g. Environments, Roles and Services) and then uses identifiers to reference instances of these objects from within the organisational structure of the learning unit. In contrast, the Nugget model contains all of its components within a single hierarchy and uses longer, free-form text strings to describe each item. The absence of references in the Nugget model means that items need to be repeated if they are to be used more then once in a single learning activity. This means what we loose in conciseness we gain in more human understandable metadata.

When a simplified version of both models are shown side by side in Figure 2, it can be seen that the basic objects of the learning activity nugget model clearly map to corresponding objects within IMS-LD.

From our comparison of these two models, we have been able to map metadata from the nugget description into that of Learning Design. The nugget 'Tasks' are essentially the same objects as 'Learning-Activities' within IMS-LD. This in turn makes 'Learning Objectives' object equivalent to 'Activity-Structures', which are collections of 'Learning-Activities'. The top level 'Nugget' object in our model, whilst containing some metadata that is stored in different parts of the IMS-LD model, most aptly fits in at the 'Component' level, as this top level object contains the roles, activities and environment elements. A complete analysis of each metadata mapping is out of the scope of this paper, so instead the more important technical issues of converting between the two are discussed in the next section.

Converting Nugget Description to IMS-LD

To further explore the relationship between the Nugget description model and IMS-LD, we modified RELOAD to perform an automatic translation from a Nugget description (described in our XML schema) into an IMS-LD manifest file.

As previously shown, the metadata in our nugget model is mostly descriptive and can be easily mapped to corresponding LD elements that describe the components related to a learning activity; however these fail to address the elements of LD related to execution. The challenge is to make an executable LD from a nugget, albeit a simple runnable Level-A LD. Part of the difficulty is due to the nature of the nugget approach and its primary purpose of promoting appropriate teaching methodologies. As a result, some of the fields deemed to be mandatory for the execution of a LD are not mandatory in the nugget model.

Another problem is the lack of an adequate formal mechanism for specifying the workflow or how it should be delivered. Although a sequence element does exist in a nugget, it is an unformatted, human-readable text string and so sequences which may have been specified by the nugget author cannot be understood by an automated conversion utility.

To address the above issues, several assumptions have to be made. The first assumption is that all the relevant fields in the Nugget have been entered appropriately. Another is that the tasks in the nugget should be executed in the order they are appear in the nugget document. With this assumption, the generated LD will present all the tasks of a learning outcome as a linear sequence of learning activities within an activity-structure. There will be no specific time limits for the completion of activities unless specified in the task length field of the nugget model. If authors require more flexibility, they can restructure the sequence of activities, change the completion conditions on activities or add new activities and resources using a LD editor such as RELOAD.

If multiple roles exist in the nugget, it brings a further complexity in generating a runnable LD. If only a single role exists, all the tasks in the nugget will be learning activities within a single activity structure, which in turn will be a reference in a role part, within an act, within a play. However if multiple roles are specified in the nugget, the mapping to LD is not straightforward and there are several possible solutions to the problem. One way is to give *each role its own act* within a play. The advantage of this solution is the roles can be synchronised with each other before entering another act related to other roles. However, this might not be the intended outcome of the nugget author and it is difficult to keep track of each role and their synchronisation points.

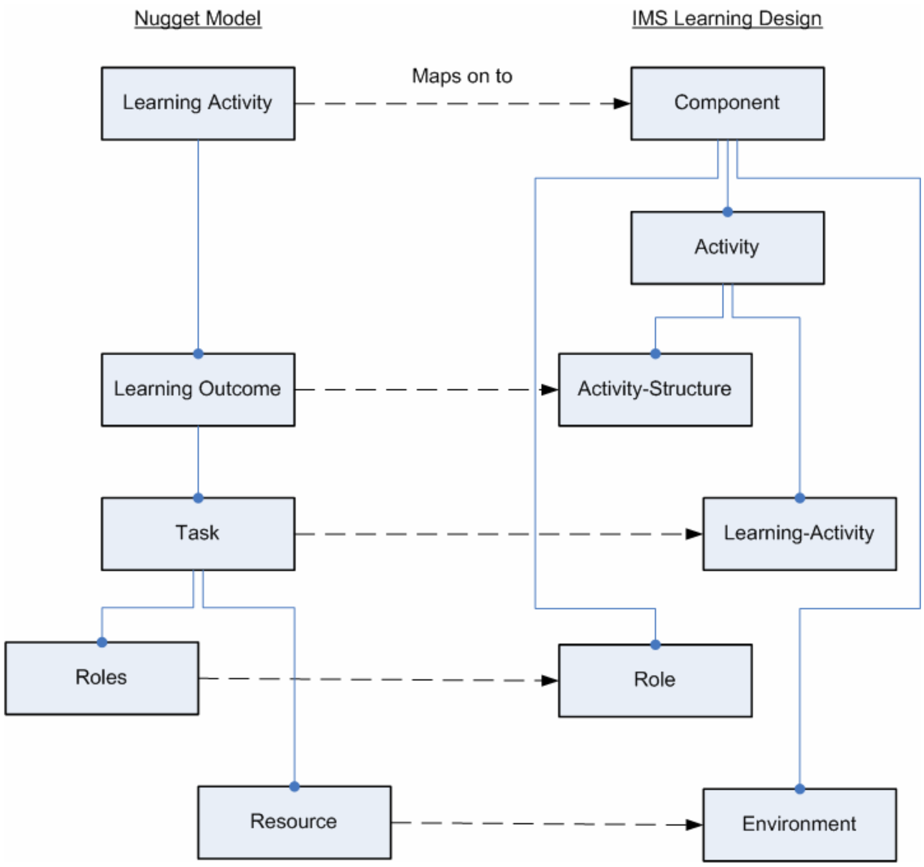

Figure 2. Mapping the major components of the Nugget Model onto IMS-LD

A second solution is to assign *all roles to the same act* so that the final LD has a single method, consisting of a single play with one act containing all the roles from the nugget. This would make the LD conceptually very simple to manage, however you then loose the ability to sequence events as all roles in an act happen concurrently. In addition, this approach also deviates from the way roles were designed to be used as sub-components of tasks in the nugget model.

The third solution, and the one chosen for our conversion routine, is to assign *each role to a play*, where the play has a single act containing the learning activities needed to be performed by a single role. Although this is not the intended use of the play mechanism in IMS-LD, this method has been chosen because it results in a less complex LD than the first solution by making it easier to keep track of which roles are associated with each activity, and is more flexible then the second solution, as the editing of activities from a single role does not cause interference to the flow of activities in other roles in the method.

This work shows that while the nugget model isn't sufficient to completely map onto all aspects of IMS-LD, by applying the modifications mentioned above and mapping the available fields of the nugget model to that of Learning Design, is it possible to automatically generate a 'basic' LD. The nugget is primarily mapped to Learning Design's Learning-Activities and Activity-Structure objects but has no support for higher organisational structures that appear in Levels B&C of LD, so the converted design will consist of a single Method, containing one or more Plays, each containing a single Act. However the design can only be deployed if all the necessary fields in the nugget have already been filled. If any of the mandatory LD metadata is missing from the nugget model the authors will still need to use the features of a LD editor such as RELOAD to flesh out the design. An LD editor also allows authors to attach digital resources, specify services or provide finer grain control over the order of activities and the rules for completion of those activities.

Analysis

Having achieved the conversion of our nugget model into the IMS-LD specification, we are now able to look further at the similarities and differences between the two approaches and comment on what might contribute to the improved functionality and usability of both.

Reflection on the Nugget Model

In analysing the relationship between the two approaches to modelling leaning, it becomes clear that for the nugget model to be used to describe more generic learning activities such as courses and modules, it would require higher levels of organisational structure above that of the current tasks, outcomes and nuggets. This would reflect the higher levels of sequence composition that IMS-LD employs with its Plays and Acts.

As previously described, there are concerns about specifying the sequence of tasks within a nugget. Our method is more flexible, but less precise, than the content manifest and organisation approach adopted in the Reload tool. However, one of the drawbacks of Reload is that it presupposes and enforces linearity which may not serve the learners very well.

As a tool for creating deployable LD modules, our conversion utility cannot guarantee that all nuggets can be converted to executable IMS-LD. However, we see possibilities for our approach to be used as a planning tool for LD within the design phase of learning unit development, before a tool such as RELOAD becomes useful. Our nugget toolkit can be used to guide practitioners in this planning phase as they initially elaborate their aims, objectives and tasks, all based on sound pedagogical principles. A completed nugget could then be converted into a skeletal LD template and authors, using a LD editor, could fill in the missing metadata, attach physical resources and package up the content ready for delivery.

Reflection on IMS-LD

While there are things to learn which impact on the nugget model, we can also reflect on issues raised by our work that concern IMS-LD. One important question that was highlighted relates to the positioning of learning objective information. The IMS specification allows learning objective resources to be placed only at the Method and Learning-Activity levels of Learning Design, however in our nugget model, learning objectives are stored as Learning Outcomes objects and these objects map best to the Activity-Structure component of LD. This is problematic because Activity-Structures cannot have certain metadata such as pre-requisite information, structure descriptions or learning objective metadata associated with them (IMS LD, 2005). In our conversion process we can circumvent this issue by replicating learning objective data and placing it at each of the atomic Activity objects, however this raises a question about the apparent limitation in LD. This restriction on the placement of metadata has been raised in other work with learning design (Paquette & Rosca, 2004). If we were able to suggest an area where IMS-LD could be improved, it would seem sensible to allow designers to attach learning objective metadata at all stages of a Learning Design not just at the highest or lowest levels.

Reusability is a central concern in the LD community and there have been many debates on the subject of just how reusable components of a design for learning really are (Kraan, 2003; Feldstein, 2002; Welsch, 2002; Jacobsen, 2001). This is in part because of the related question about how reusable a single resource is when taken out of the situated context in which it was originally used (Downes, 2003). In LD, that context is made explicit such that, in order to reuse a component, designers would be required to re-author much of the surrounding contextual metadata. In our project, we have found that the most desirable aspect of our nugget model is not principally to identify *what* resources are used, but rather *how* a specific subject is being taught by others. We believe that while the debate on long-term reusability of LD is still undecided, a tool such as ours can greatly increase the perceived reusability of learning design templates by providing a mechanism for abstracting the 'design' of learning activities separately from the business of making executable units of learning.

Another important issue when building descriptions based on strong pedagogical foundations is the need to identify and label the types of assessments being used. In the nugget model, Assessments are a form of Tasks with additional metadata describing the type and form of the assessment. Converting this model into IMS-LD revealed a difficulty in that LD does not handle assessments itself, but instead relies on an external specification for modelling questions and tests called QTI (IMS QTI, 2005). This could be problematic as the general design of learning activities by practitioners is so closely tied with that of their assessment. The separation of the two, while useful for implementation and specification reasons, might cause problems in the transfer of design approaches. By excluding assessment information from LD, a single specification is not available to fully describe a unit of learning. Furthermore, authors should not need to be aware of the existence of the two different specifications. This is really an issue for the design and development of editors and as such these future tools will not only have to support both standards, but also need to be user friendly to foster the long term adoption of learning design.

Conclusions

This paper describes the underlying model of an online tool that supports teachers, and other learning activity creators, as they create nugget descriptions and store them alongside others contributed by a growing community of practice. It incorporates a set of pedagogically driven metadata that can be used to describe learning nuggets and as a basis for discovery and retrieval from digital repositories. The metadata items are selected from carefully defined, but extensible, taxonomies.

Analysis of, and comparison with, the IMS-LD specification revealed that our framework supports teachers in the earliest stages of planning online learning, whereas IMS-LD concentrates on representing interoperable and runnable learning designs. Thus, our work has potential as a pre-editor for IMS-LD to promote good pedagogical design. Our nugget model focuses on describing individual learning activities, rather than programmes of educational teaching, and has highlighted the need for IMS-LD to provide more opportunity to specify metadata at each of its hierarchical levels. It also indicates a requirement for more extensive metadata explicitly describing the approach to learning and teaching.

Our conversion utility, integrated into the RELOAD editor, provides a mapping between our fields and the metadata fields of IMS-LD. While the majority of fields have equivalents in both models, it is not possible to guarantee that all nuggets can be converted into executable IMS-LDs. Our analysis reveals critical changes that could be made to both models such that they better support the needs of practitioners in describing real learning activities.

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Zarraonandia, T., Dodero, J. M., & Fernández, C. (2006). Crosscutting Runtime Adaptations of LD Execution. *Educational Technology & Society*, 9 (1), 123-137.

Crosscutting Runtime Adaptations of LD Execution

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ABSTRACT

In this paper, the authors describe a mechanism for the introduction of small variations in the original learning design process defined in a particular Unit of Learning (UoL). The objective is to increase the UoL reusability by offering the designers an alternative to introduce slight variations on the original design instead of creating a new one each time they want to reuse it. No changes or extensions to the Learning Design definition are required to perform these modifications. The use of design patterns to include the adaptations offers the possibility to easily introduce new operations, such as tracing the activity progress, for instance. The structure of a Learning Design player that is able to process the desired adaptation information and to apply it at runtime will be outlined. The player will be part of an architecture for the automatic adaptation of UoLs to their actual context of execution.

Keywords

Learning Design, Unit of Learning, Adaptation, Adaptive Systems, Context

Introduction

A Unit of Learning (UoL) is obtained when a description of an LD is included in a content package manifest (IMS, 2003b). The Unit of Learning encapsulates all the information required to go through the learning process, including both pedagogical information and information needed to locate and use the required resources. An appropriate tool called a learning design player can open the Unit of Learning and provide the participants with an appropriate interface to perform the activities during the learning process (IMS, 2003a). The IMS LD specification defines three levels of implementation and compliance (IMS, 2003b). Level A contains the core of the Learning Design, providing a vocabulary to specify a sequence of activities to be carried out for the learners and teachers who take part in the learning process, while Levels B and C allow the designers to define a more elaborated sequencing of the process (Jeffery & Currier, 2003).

A Unit of Learning is designed for execution in a particular environment and under the assumption that some specific conditions are satisfied. Its execution under different conditions does not guarantee that the expected results will be obtained and the whole process should be revised. However, sometimes light modifications – e.g. replacing the resource associated with a particular activity, modifying the presentation order, etc. – would make it possible to reuse most of the original processes in a new situation. For instance, we have developed a Unit of Learning for a particular course taught at our university. Now we have to use the same course to train the employees of a company. The computers used for training in the company are less powerful than those from the university and we know the bandwidth of the network is far smaller. Therefore, some of the activities proposed in the original Unit of Learning may not be suitable for the new conditions. However, the rest of the process remains quite similar. Later on we may want to reuse the course to train a different audience and similar situations can occur. The instructor is forced to create a new UoL for each of the courses even when they all implement the same learning process.

Furthermore, in practice, total reusability of the UoLs is not an easy objective to attain as, even when applied to very similar situations, the introduction of small variations on the learning process is usually required. From one semester to another authors may desire to replace some of the resources for more up-to-date files, to remove the activity environments to test learner's knowledge without helping resources, to introduce a presentation of the course for the current audience, to modify the question item order, etc. But like in the previously mentioned situation, each modification requires redefining the whole UoL.

Keeping different UoLs for each variation of the process could be an adequate approach when the number of UoLs is not large and their complexity is low, otherwise the costs of maintenance are high. On the other hand, designers can use level B elements to modify the UoL runtime behavior based upon the value of different properties. The system proposed by the ALFANET project takes advantage of this characteristic and is able to recommend to each individual learner the most appropriate material taking into account the interactions performed by a group of similar learners (Alfanet, 2005). However, in any case, that material must be included into the course before its use. It is not possible for the designers to know in advance the range of adaptations that may be required to apply in the future, and for that reason the UoL will have to be redesigned each time a new modification comes into place. In addition, one adaptation can involve changes at different places of the UoL. As the number of adaptations applied to the UoL increases, it becomes more difficult to identify which change corresponds to which adaptation and operations like adaptation removal may become difficult to carry out.

Jacobson et al (1997) defined variation point as "places in the design or implementation that identify locations at which variation can occur". Variation points can be bound to the system at different stages of the product lifecycle. Svahnberg et al. (2002) presented a taxonomy of variability realization techniques which defined different ways in which a variation point can be implemented. One of these techniques is the code fragment superimposition, where a software solution is developed to solve the generic problem; code fragments are superimposed on top of this software solution to solve specific concerns. This superimposition can be achieved by means of different techniques, as for example the aspect oriented programming approach, and provides the designer the possibility to bind the modification during the compilation phase or even at runtime.

Taking these concepts into the adaptation of the UoLs area we can define an alternative approach to the Level B usage. The authors can describe the desired adaptations on auxiliary specification files that could be processed together with the original UoL and applied at runtime giving the user the feeling that they were included on the original UoL. This way, we can maintain a single UoL definition and a number of descriptions for adaptations. Those files tie together all the changes involved on a particular adaptation and keep that particular concern separated from the main UoL functionality and the rest of adaptations.

An overview of the process is shown in figure 1. From several possible adaptations defined for a particular UoL, the designer chooses the one which best fits the current situation and applies it to the UoL. The introduction of the adaptive action can be carried out at design time (adaptation 1) or at runtime (adaptation 2, 3, 4). In the last case, adaptation could be applied to all the running instances of a UoL (adaptation 4), to all the users of a particular running instance (adaptation 3) or only to the personalized view of a particular user (adaptation 4).

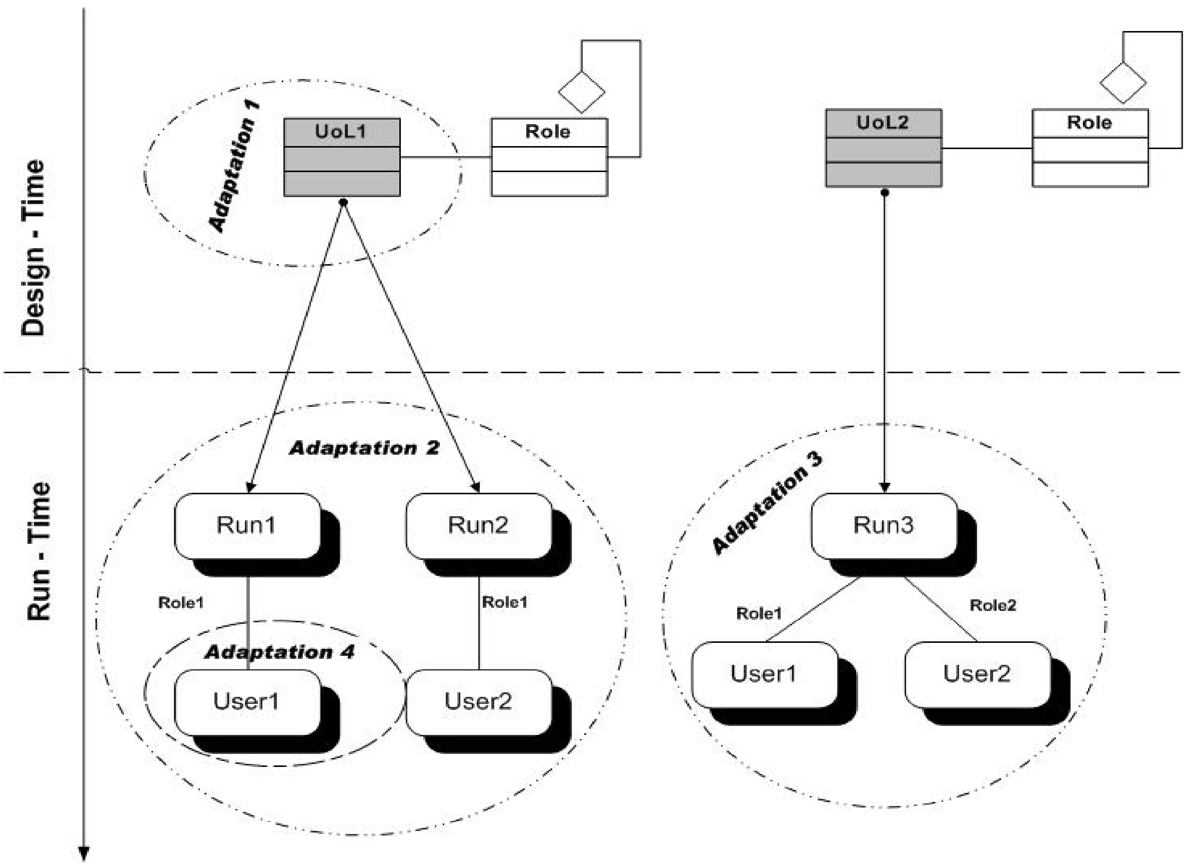

Figure 1. Overview of the adaptation process of a Unit of Learning

Two kinds of adaptive actions over a Unit of Learning can be defined: adaptations for its reuse in a specific situation and adaptations for its reuse in a context different from the original it was defined for. In the last case, the characteristics of the current environment of execution of the UoL can be captured, and the adaptation application automated.

In this document, we outline the architecture of a system capable of processing contextual information and automatically taking adaptive actions on a Learning Design. The core of the system is an LD Player able to adapt at runtime a UoL execution. The player is designed as an extension to the CopperCore runtime engine and is implemented with the help of different design patterns and an Aspect Oriented Programming approach.

The rest of the paper is organized as follows. First, a description of the adaptation capabilities of the Learning Design Player engine is presented. Second, its structure is outlined. Next, the implementation details are provided. Then, some examples of UoL adaptations are described and the architecture of the context adaptive system is introduced. Finally, some conclusions and further work are presented.

Adaptation Definition

In principle, all the Learning Design elements that are defined in a UoL manifest file can be subject to adaptation. However, the adaptation process only makes sense when it involves just small modifications of the original process. The introduction of new roles, acts, complex conditions or structural mayor changes, requires the description of complicated adaptation files, making the redesign of the original UoL a more suitable approach. Taking this into account we limit the range of possible adaptations to the following subset of the elements in an LD.

- Level A: only activities, environments and resources can be adapted. This includes the definition and association of new resources with existing activities or environments, the introduction or removal of these types of elements and some modifications to their original definition.
- Level B: modifications of the definition of properties, conditions and the values of the elements “when-property-value-is-set” and “change-property-value”.

We define an *adaptation poke* as the description of a small modification of some elements in a learning design process. To describe an adaptation poke three different types of files can be specified:

- Adaptation command files: Containing the list of adaptation commands to be applied sequentially to the original Unit of Learning definition. It is the only mandatory file for the definition of an adaptation poke. Table 1 shows the possible adaptation commands. Note that for each command there exists an equivalent *commanameT*, providing the same functionality but using the title of the elements instead of the id.
- Adaptation manifests: these are XML files containing the definition of new activities, environments, resources, properties or conditions. These definitions will be incorporated to the set of Learning Design elements definitions that are read from the original UoL manifest. If a condition element definition is found, it will override the condition definition of the original manifest. The schema definition of this type of file is based on the XSD binding for the Learning Design Definition Model (IMS, 2003c) for the above-specified elements.
- Resource files: new content files.

Adaptation pokes can be applied to the UoL at publication time if they are included into the content package. The Learning Design Player will process the files together with the original information and apply the changes before the information is presented to the participants of the process. Pokes must be numbered, and if more than one is included in the package the Learning Design Player will apply them sequentially.

To perform the adaptation on a running UoL instance, the adaptation poke files should be uploaded to the Learning Design Player specifying the UoL, run and user instance for which the adaptation should be applied.

In case of conflict between the definition of the poke and the UoL the whole poke will not be applied and the designer will be reported about the reasons. This is especially important when applying several pokes to the same UoL as the structure of the original LD may be modified and some activities, environments and resources associated to definition of the latest pokes may have been modified or even been removed. Besides, the modification of Level B properties and conditions can generate deadlocks; the original learning objectives can be changed and also must be taken into consideration the actual stage of the participants in the learning process in order to avoid inconsistencies. The final version of the adaptive LD Player will include a mechanism to automate the detection of such conflicts when possible.

Table 1. List of adaptation commands

State Change Commands	
LEVEL A	
Actions on Activity Structure elements	
Change title	ASchgTitle idActivity, newTitle
Actions on Learning Activity elements	
Change title	LAchgTitle idActivity, newTitle
Change the resource reference of an Item element of the activity description	LAchgDes idActivity, idItem, idItemRef
Set the *complete-activity* definition of the Learning Activity (user choice | time limit)	LAcomp idActivity, newoption
Change the resource reference of an Item element of the feedback description of the on-completion	LAoncomF idActivity, idItem, IdItemRef
Actions on Support Activity elements	
Change title	SUchgTitle idActivity, newTitle
Change the resource reference of an Item element of the activity description	SUchgDes idActivity, idItem IdItemRef
Set the *complete-activity* definition of the Support Activity (user choice | time limit)	Sucomp idActivity , data
Change the resource reference of an Item element of the feedback description of the on-completion	SUoncomF idActivity, idItem, IdItemRef
Actions on Environment elements	
Change title	ENchgTitle idEnvironment, newTitle
Change the resource reference of an Item element of the learning-objects definition	ENchgDes idEnvironment, idLO, idItem, IdItemRef
Actions on Resources	
Change the file reference of a resource*	REchg idResource, href
LEVEL B	
Actions on Property elements	
Change the initial value of a property	PRini idProp, value
Actions on Learning Activities	
Set the *complete-activity* definition of the Learning Activity to when-property-value-is-set	LAcomPv idActivity, propRef, propValue
Set the on-completion definition of the Learning Activity to change-property-value	LAoncomC idActivity, propRef, propValue
Actions on Support Activities	
Set the *complete-activity* definition of the Support Activity to when-property-value-is-set	SUcomPv idActivity, propRef, propValue
Set the on-completion definition of the Support Activity to change-property-value	SUoncomC idActivity, propRef, propValue
Structural Change Commands	
LEVEL A	
Actions on Activity Structure elements	
Add a new activity to the structure	ASaddAct idActivity, idActivity, pos
Remove an activity from the structure	ASrmvAct idActivity, idActivity
Actions on Learning Activity elements	
Add a new environment element	LAaddEnv idActivity, idEnvironment
Remove an environment element	LArmvEnv idActivity, idEnvironment
Actions on Support Activity elements	
Add a new environment element	SUaddEnv idActivity, idEnvironment
Remove an environment element	SUrmvEnv idActivity, idEnvironment
Actions on Environment elements	
Remove a learning object element	ENrmvLo idEnvironment, idLO

* This action replaces the file definitions of a resource of type “webcontent” with the specified *href* reference.

Learning Design Player Structure

A Learning Design Player (LD Player) is the program that interprets a Unit of Learning. It presents the different activities and resources to the relevant roles and controls their interactions. The conceptual model of the Learning Design specification is expressed with a mapping to object-oriented design in mind, which naturally suggests an implementation of the LD Player by means of Object-Oriented Programming (OOP) techniques. It is straightforward to establish a correspondence between the elements of the Learning Design specification and the class concept from an OO approach.

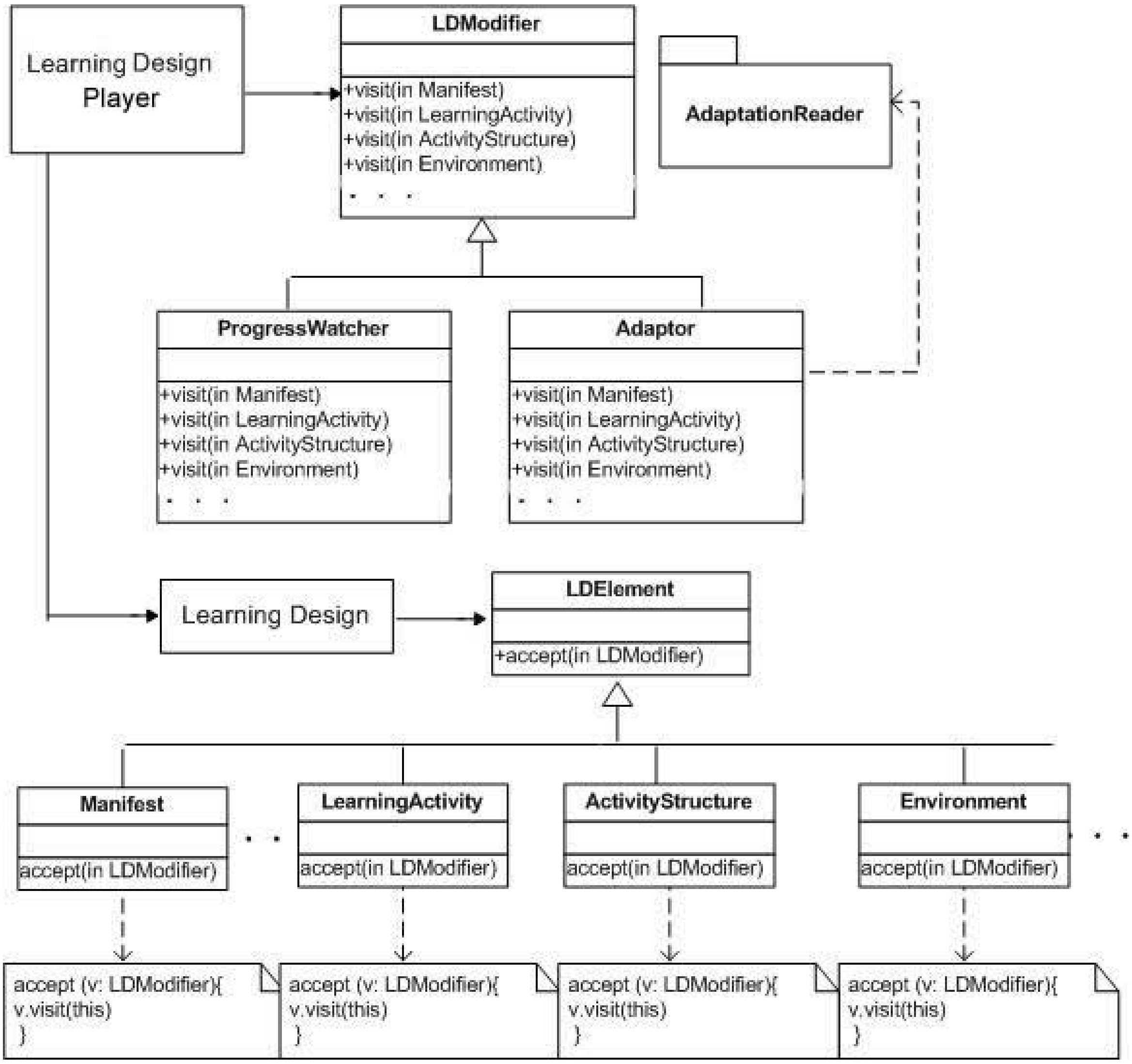

Figure 2. LD Player structure

Different changes have to be applied to the elements of a Learning Design in order to perform the required adaptations. We cannot foresee which future modifications will be required and we do not want to change the structures of the elements each time a new adaptation is required. This scenario corresponds to the one described for the visitor design pattern (Gamma et al., 1995): *"To perform the same operation on the elements of an object structure and be able to define new operations without changing the classes of the elements of the structure"*. In this case, the elements of the structure are the elements of the Learning Design subject to adaptations, and the operation is the proper adaptation, or any other operation to be performed on the elements such as measuring the learner progress on the activities, for instance.

To implement this organization it is necessary for the elements of the Learning Design to include an *accept* operation. This operation will receive an *LDModifier* object as an argument. The LDModifier object includes a "visit" method for each type of element of the manifest definition. The correspondent type of elements of the LD will respond to its *accept* operation by calling the adequate "visit" method of the received *LDModifier* (Fig. 2).

For each running instance of the Unit of Learning there will be only one instance of the *Adaptor* class, which inherits from *LDModifier* and encloses all the changes associated to the adaptation files, which are the changes that should be applied to the elements of the Unit of Learning for its actual execution. Once the original Unit of Learning information is read, the *accept* operation of the *manifest* element can be called, passing the *Adaptor* instance as an argument. This will trigger the manifest *visit* method of the *Adaptor*, which will retrieve, one by one, the different elements for which an adaptation has been defined and, in order to perform the appropriate changes, call their accept operation passing the *Adaptor* instance again. Figure 3 illustrates this process.

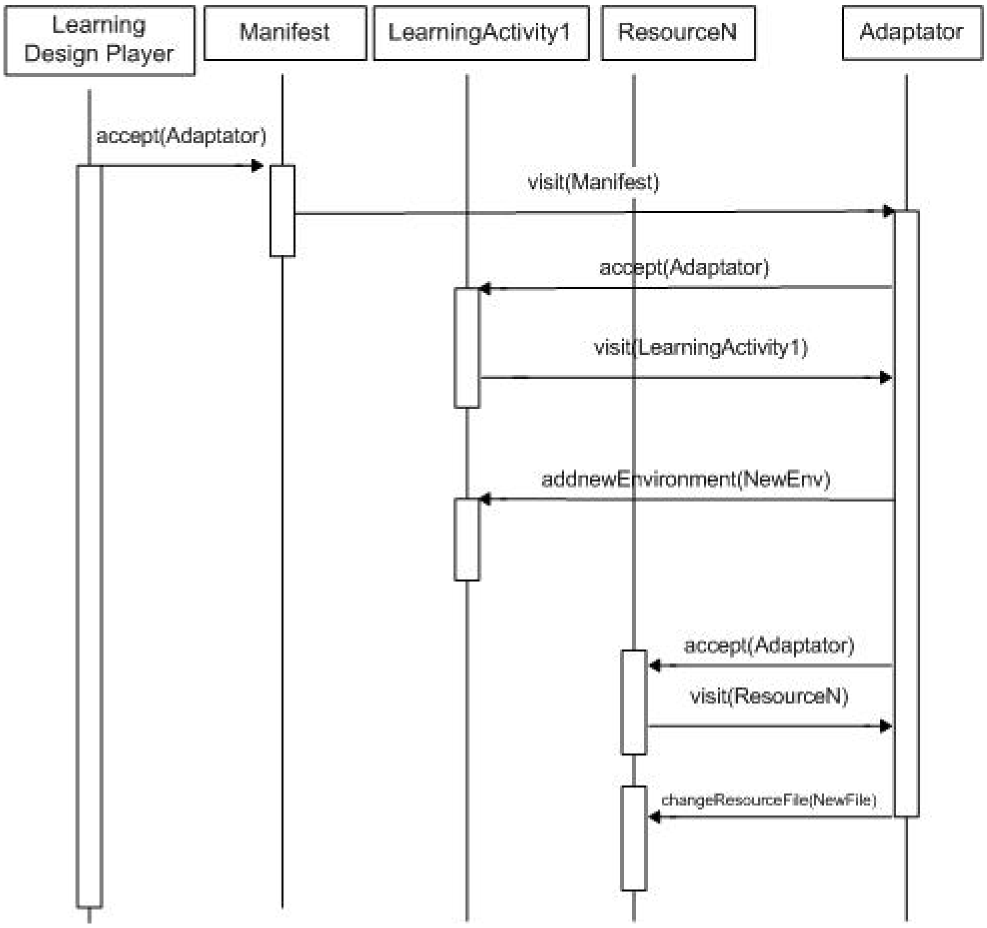

Figure 3. Sequence diagram of an adaptation poke application

Future adaptations can be easily performed. We only have to create the new adaptation files and include them in the content package together with the original ones or upload them to a running instance. The *AdaptationReader* will generate the appropriate *Adaptor* object and pass it to the execution engine for its application.

The addition of new operations over the elements of the structure is also smooth. For example, we can create a *Progress Watcher* class that inherits from the *LDModifier* and retrieves through its *visit* methods information about the different components of the Learning Design (property values, resources visited, time spent on a particular activity, etc). Since it extends the *LDModifier* class, we can pass this type of object as an argument to the *accept* operation of the Learning Design element classes. These will call the *visit* operation of the *ProgressWatcher,* what is performed without any change on the class interface. For the elements of the Learning Design the particular type of *LDModifier* received by the *accept* operation is transparent. The *Progress Watcher* implementation on the Learning Design Player could complement a *Monitor Service* actuation or constitute an alternative approach to its implementation on those UoLs not concerned with monitoring and for which the information retrieval is a requirement in a particular learning session.

The organization is easy to maintain and only if future specifications of the Learning Design should consider new types of elements, the interface of the *LDModifier* would be modified to include new operations for the new elements.

Implementation

The adaptive LD Player is implemented as an extension to the CopperCore IMS Learning Design engine (OUNL, 2005). The CopperCore engine has been created by the Open Universiteit Nederland (OUNL) and is capable of processing the three levels of IMS Learning Design. It is not designed as a standalone application but to be integrated into existing e-learning infrastructures (Kraan, 2004).

Aspect Oriented Programming Approach

The implementation of the design as previously described requires modifying some of the elements of the Learning Design to include the new operation *accept*. The first approach would be directly modifying all the elements involved in the process, which means modifying the CopperCore engine code. From the point of view of the software, flexibility and modularity, another possibility seems to be much more suitable: the use of an Aspect Oriented Programming approach.

Aspect Oriented Programming (Marcus, 2001) extends the object-oriented paradigm by introducing the concept of aspect, which encapsulates cross-cutting behaviors that affect multiple classes into reusable modules. Aspects are defined separately from the classes and methods that make up components at design time, and compilers and interpreters are in charge of the integration according to some supplied criteria and before the conversion into binary code.

Following these ideas, we can simulate the *accept* operation of the elements of the LD by defining our *LDModifiers* as separate aspects and establishing the conditions in which the normal execution of the elements will be intercepted to launch the new code. This way new aspects and launching conditions can be added or removed without any alteration on the Learning Design structure.

Furthermore, the use of this approach results in a more flexible structure, which allows the maintenance of the adaptive extension files separated from the specific CopperCore code. This facilitates the upgrade of the extension to new CopperCore engine versions.

Adaptation Examples

In order to clarify these adaptations we illustrate some adaptations realized with examples taken from the OUNL DSpace repository (OUNL, 2003). The first one corresponds to a IMS LD Level A course and the second one to Level B. At this moment no authoring tool has been developed to automatically create the adaptive information files so manual editing is required. However, following the objectives of the process, its definition is straightforward. Next, we will explain the examples in detail.

Level A adaptation. The Candidas example

"Candidas .The Great Unknown (I)" is an example of a simple course in level A developed by the Open Universiteit Nederland. It is composed of one act, one role and one single learning activity structure. The learner will go through an initial introduction to the material and different expositions; each one is followed by the corresponding questionnaire.

Adaptation Poke 1: Remove test activities.

In this adaptation poke teachers want to remove the test activities from the Candidas course. To modify the original *activity-structure,* an adaptation command file will be introduced into the original UoL including the following orders:

```
Adaptation command file:

   ASrmvAct       AS-learningactivity,    Test-1
   ASrmvAct       AS-learningactivity,    Test-2
   ASrmvAct       AS-learningactivity,    Test-3
```

```
ASrmvAct        AS-learningactivity,    Test-final
ASrmvAct        AS-learningactivity,    Feedback
```

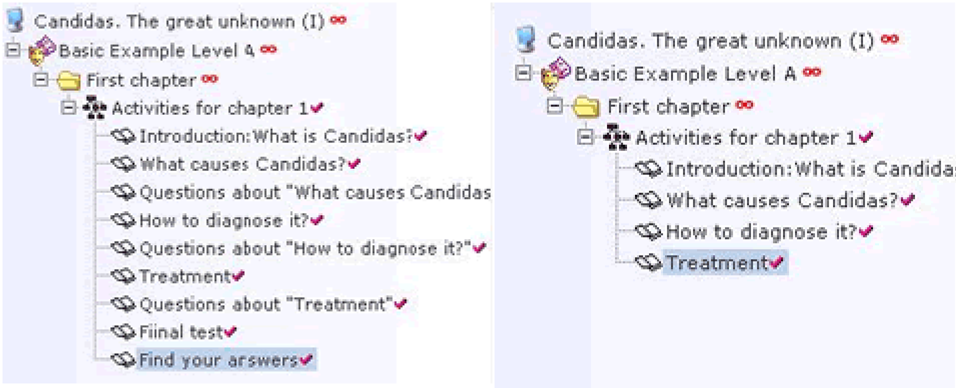

Figure 4. Structure of the course before and after the adaptation

Figure 4 shows two screenshots of the original course structure (left) and the structure after the adaptation poke is introduced into the UoL (right).

Adaptation Poke 2: Remove test activities and include a teacher presentation.

The objectives of this adaptation are to remove the tests and to add a teacher's presentation including his contact information.

A new adaptation poke will be defined. It will be composed of an adaptation manifest file holding the description of a new activity *"Presentation"*, a new file resource associated with it, a new content file (*Presentation.html),* and an adaptation command file for adding the new activity to the activity structure.

```
Adaptation manifest file:

<imsld:activities>

   <imsld:learning-activity identifier=" Presentation ">
      <imsld:title>Presentation</imsld:title>
      <imsld:activity-description>
           <imsld:item identifierref="R- Presentation " identifier="I-
                        presentation "/>
      </imsld:activity-description>
      </imsld:learning-activity>

   </imsld:activities>

<resources>
      <resource identifier="R-Presentation" type="webcontent"
                href="presentation.html">
          <file href="presentation.html"/>
      </resource>
   /resources>

      Adaptation command file:

   ASaddAct   AS-learningactivity,  Presentation,  1
```

The new adaptation poke will be applied on top of the one described in the previous point. Figure 5 shows the teacher's presentation appearance after being added as a new activity of the course.

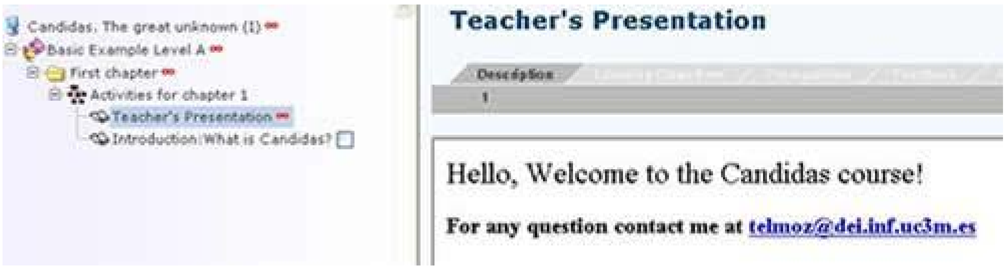

Figure 5. Teacher's presentation

Level B adaptation. Learning to listen to Jazz example.

"Learning to listen to Jazz" is another example developed by the Open Universiteit Nederland. It describes a Level B course on the jazz music genre. It is composed of one act and two roles and the learner will have the possibility to follow the course by two different knowledge routes: thematic or historical. At the beginning of the course, the learner introduces some personal data, and after some initial testing she makes her choice about the knowledge route she wants to follow. Later on during the course, she will be asked about the grade of satisfaction on her decision and she will have the possibility to change to the other knowledge route.

Figure 6. Orientation activity environment before (left) and after adaptation (right)

Adaptation Poke 1: Force the learner to go through the historical route.

The instructor wants to reuse the course but obliging the learner to go through the historical route. No initial knowledge or study approach test must be presented. For this to be achieved several modifications will have to be applied:

- ➢ The property related to the route election will be loaded with an initial value in order not to give the learner the possibility of choosing.
- ➢ The environment of that activity will be removed. This way the initial tests will be hidden.
- ➢ The activity 'reflection in the meantime' will be removed from the historical route activity-structure. This will block any possibility of changing to the thematic route during the course execution.

The adaptation poke will include the definition of an adaptation command file that contains the following three commands:

```
Adaptation command file:

PRiniT      option, historical
LArmvEnvT   orientation, What do you already know?
ASrmvActT   historical route, reflection in the meantime
```

Figure 6 to 8 show different screenshots of the course aspect before and after the application of the adaptation poke. Tests disappear from the '*orientation'* activity (fig. 6) and no possibility to elect the knowledge route is presented to the user (fig. 7). The 'reflection in the meantime' activity is also removed from the 'historical route' activity structure (fig. 8).

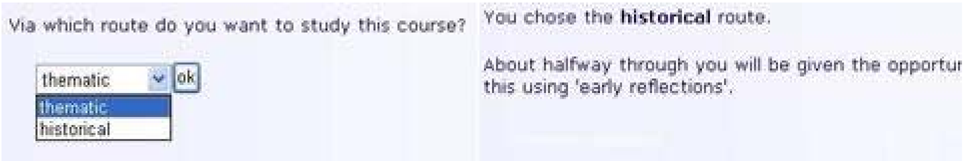

Figure 7. Orientation activity content before and after adaptation

Figure 8. Structure of the course before and after the adaptation

Contextual Adaptations

It is very unlikely that a UoL could be reused exactly the same way in a different context from the one for which it was designed. Different learner characteristics, execution environments or time schedules, for instance, may require serious modifications of the definition of its Learning Design elements and a new redesign of the UoL considering the new characteristics of the new environment could be more appropriate.

However, other times, when the new context situation is close to the original one, reusability could be achieved by the introduction of specific variations on the process. This way, we can have an original UoL, and a set of possible modifications that will adapt the learning process to a predefined set of context situations. The characteristics of the actual context of execution can be captured and the best suitable adaptation applied in order for the learners to obtain a better-tuned process to follow.

This way, two possible sources of adaptation pokes can be found. On one hand, we have the adaptations the designer has defined for a learning process in order to solve specific situations in different courses. On the other hand, a set of context adaptations could be defined to make the Unit of Learning adequate for different environments of execution. Figure 9 describes the general process of adaptation of a Unit of Learning. The *ContextReader* gathers the features of the current environment of execution, determines which is the current context situation and automatically applies the appropriate context adaptation. On top of that, the designer may apply her own modifications to the process to solve a specific problem or to optimize it.

Context Model

Many definitions and different meanings for the term context and context-aware computing can be found in the literature (Chen & Kotz, 2000; Pasco, 1998; Schilit et al., 1994). In Dey (2001) the author defined context as "any information that can be used to characterize the situation of entities that are considered relevant to the interaction between a user and an application, including the user and the application themselves". On another hand, Schilit et al. (1994) defines context-aware computing as "software adapts according to the location of use, the collection of nearby people, host, and accessible devices, as well as changes to such things over time".

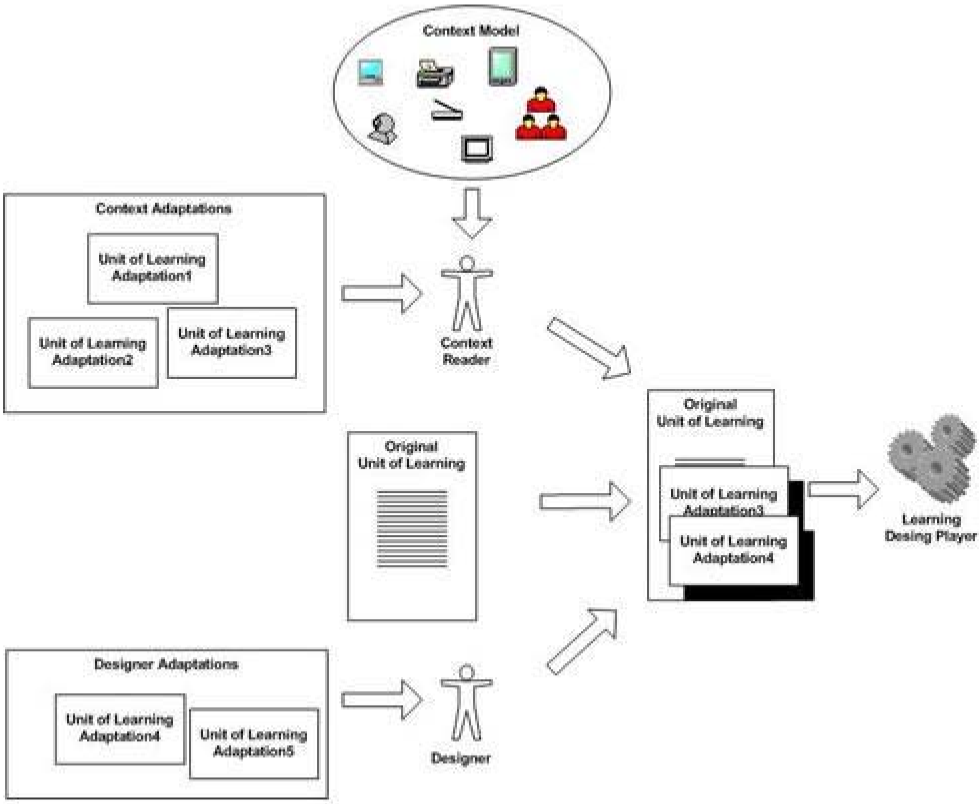

Figure 9. Overview of the context adaptation process

For our purposes, context will be any information that can be used to characterize the learning process, that is, any relevant information that could influence the execution of a Unit of Learning. This definition of context covers information about the computational environment (availability of different devices like printers or scanners, network connection bandwidth, computer characteristics, monitor resolution, etc) as well as physical and psychological characteristics of the user (age, background, disabilities, preferences, agenda) or information about the environment in which the learner is placed (location, weather conditions, other users availability, etc).

Every UoL is constructed having in mind a particular context, and to check its adequacy to the current context, different UoLs may require collecting different contextual information since the information that is relevant for a particular process may not be significant for another. Then, it is necessary to define which contextual data are significant for each learning process and how they should be obtained. We store that definition together with the definition of the UoL, and an ambient intelligence device can retrieve the actual values of the contextual information from different sources like sensors, operating system, user profiles, etc.

We consider a Learning Design context (Fig. 10) as any combination of context elements that can be classified in four types:

- Boolean Context Elements: Context elements with only two possible values: true or false. This type of element is adequate to denote the presence of connected devices, other learners, etc. We can define different associated attributes to represent different characteristics and properties of the elements. For example: to represent the availability of a printer, we can define a Boolean context element named *Printer* with attributes *color* and *resolution*.

- Continuous Context Elements: In this category we group context elements whose value can be measured on a continuum or scale. The presence of the element is always true, but its intensity is variable. This kind of elements is appropriate to represent the lighting, noise level and other characteristics of the environment. In order to facilitate the work with these types of elements we can divide the range of their possible values into different sub-ranges. For example: for the context element *Lighting* we can define the ranges *Low* for values under 300 lux, *Medium* for values between 300 and 500 and *High* for greater values. If the actual value is 400, the *activeRange* would be *Medium*.
- Discrete Context Elements: This group includes context elements whose value is defined only for a particular vocabulary or classification. We can use this type of element to model characteristics of the user (marital status, background, occupation, etc), time and frequency terms (day of the week, months, etc), location (country, city, place), etc. As part of the definition of the element, it is necessary to provide the set of possible values or an URI to locate the specifically associated vocabulary.
- Aggregate Context Element: It is also possible to define a context element as an aggregate of other context elements. For example, we can define an element *Connection* that groups the continuous element *Bps* and the Boolean ones *Dial* and *Wireless*. The first element would indicate the speed of the connection while the other two would indicate if dialing its needed and if ubiquitous conditions can take place.

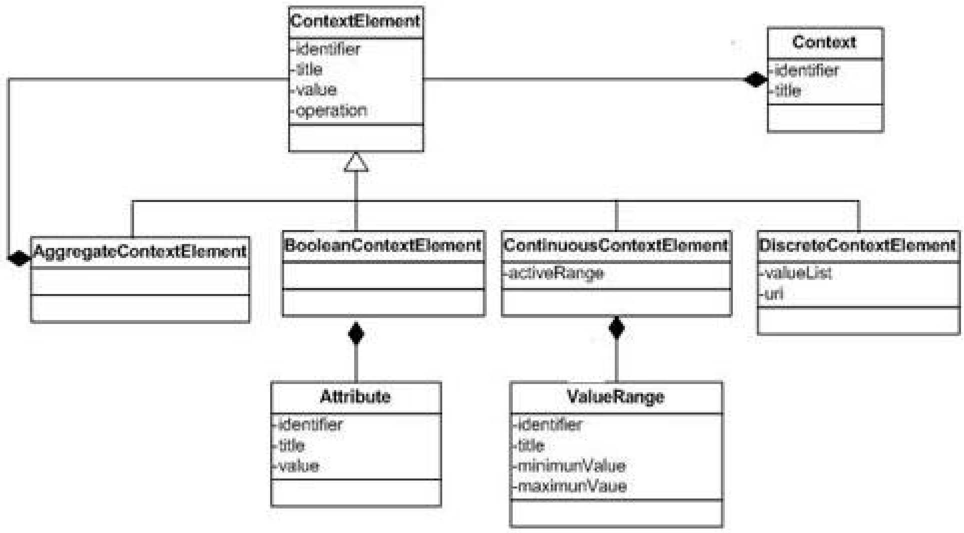

Figure 10. Context Model

The context of a Learning Design is formed by a particular collection of context elements. The same context definition can be associated to different UoLs, while in some other cases different UoLs may need different context definitions.

Before the execution of the process, the context elements must be populated with their current values for the session. The ambient intelligence engine will obtain those values by the execution of the appropriate operation, which is stored as part of the definition of each context element. The operation can consist in a specific call to the operating system or to different devices connected to the computer, to retrieve information from the learner profile, to query the user agenda, etc. Eventually, the user could be directly inquired.

Context Situation Definitions

Once we have gathered information about the context of the learning session, we have to apply the appropriate changes to the Unit of Learning. Those changes consist of small variations to the original process in order to adapt it to the new situation.

The idea is to define context situations, i.e. sets of possible values for the context elements of the LD context definition, and associate them with a set of changes to the original elements.

For example, we have developed a UoL for an Internet course that covers an introduction to different Internet related concepts and the basics of web browsers, search engines, mail and instant messaging programs (Fig. 11).

Originally, the course was expected to be taken in a classroom and the scheduled time to complete it was two hours. Now, we want to reuse the procedure but giving the learners the possibility to follow the course from their homes. As the configuration of the home computers of the learners may not always be the same and some devices may not be available, it will be necessary to introduce some changes to the original design. On the other hand, the learners are not subject to time restrictions as they follow the course with their own computers and in their spare time. For that reason it is possible to increase the assigned time to some of the units to analyze them in depth.

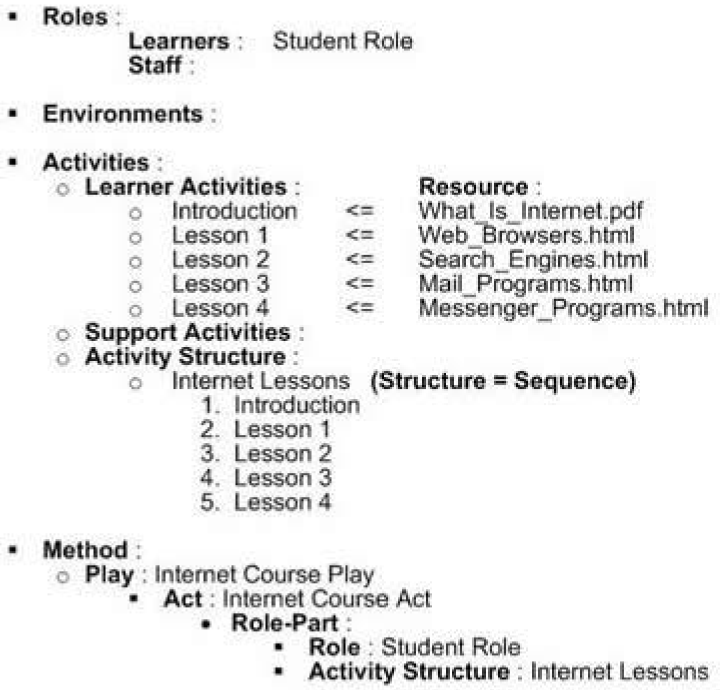

Figure 11. Unit of Learning schema for the Internet Course

Table 2 shows the elements of the context definition developed for the Unit of Learning, their possible values and the context situation names we have associated to their combinations.

If the ambient intelligence engine detects an Internet connection, a web camera, a low level of noise and an available time for the session of two hours, we can consider that the context of the learning session is quite similar to the one expected at design time. Therefore, no changes in the default process are required. On another hand, if no time constraints are detected on the user agenda, we can change the resource associated to the activity *Introductory* for a more extended document. If no web camera is available, we may want to replace the resource associated with the activity *Lesson 4*, which includes an explanation of how to proceed to configure that device for a messenger program. If the fourth combination of context element values is found, we can conclude that the user is on any transport or any other noisy environment. Her level of attention could be lower than on other context situations, and we may want to change the activities.

Table 2. Context Situation Definition

Noise Level	Time Constraint	Internet Connection	Web Camera	Context Situation
Low	Yes	Yes	Yes	Classroom
Low	No	Yes	Yes	Home1
Low	No	Yes	No	Home2
Low	No	No	-	Home3
High	Yes	No	Yes	Transport

Adaptation to the context

For each of the context situation an adaptation poke will be defined. The ambient intelligence device will retrieve the values for the context elements that are relevant to the UoL execution, and based upon those values, determinate the current context situation. Then, the set of adaptation files corresponding to its associated adaptation poke will be incorporated to the original UoL. The adapted UoL will be passed to the Learning Design Player for execution.

Conclusions and Future Work

The aim of our research is to develop a mechanism to incorporate runtime adaptation capabilities to Learning Design execution. The purpose is to increase the reusability and flexibility of the UoLs by using a simple procedure to introduce the desired modifications into the original learning process. The concept of an adaptation poke has been introduced as the specification of small adaptive actions that can be included in the delivered package and interpreted by an appropriate Learning Design Player to obtain the adaptations applied at runtime.

A Learning Design player structure with adaptation capabilities has been described. The major advantage of our approach is its easy extensibility and the lack of disruption into the Learning Design definition. The implementation is being tested as an extension to the CopperCore Learning Design engine using the visitor pattern and an Aspect Oriented Programming approach. At the time of this writing we are defining a mechanism for the prevention of conflicts between the adaptation poke changes and the UoL definition, and the final set of adaptive commands is also being refined. The final version of this application will be available as open source software.

The architecture of a system able to automatically perform adaptive actions to modify a UoL to a context execution different to the one for which it was designed has been outlined. The core of the system will be the adaptive Learning Design player previously described.

Future research lines take into consideration that by following the ideas described above, other operations like learner progress observation, or checking particular conditions of actuation, can be easily implemented. This will open possibilities to define more complex adaptations, not only based on pre-defined information but also on the evolution of the learning process. In addition, and taking advantage of the straightforward of adaptations of this approach, a user-friendly authoring tool for its description will be developed.

Acknowledments

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Learning Design, generic service descriptions and universal acid

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ABSTRACT

This paper examines the contention that learning environments which use IMS Learning Designs can be created by plugging in different components, using generic service descriptions to create the interface between the Learning Design (LD) and the specific tools. There is an alternative viewpoint which claims that generic service descriptions cannot provide the richness required to fully utilize Learning Design. The paper describes the work performed in the SLeD project by the UK Open University and the Open University of the Netherlands. The SLeD project suggests a compromise between the two viewpoints by using generic service descriptions, but recognizing the nature of the current environment through the use of translators, which interact with specific instantiations of services.

Keywords

Learning Design, service descriptions

Introduction

Over recent years there has been a considerable push towards interoperability, both within the educational sector and in terms of broader data exchange. This desire for interoperability has several motivations underpinning it. Perhaps primary amongst these are cost considerations. As it became evident that elearning was not a cheap alternative to face to face teaching, then the desire to reuse grew (Weller, 2004). The initial focus of reuse was on content, with the notion of learning objects, and building an 'educational object economy'. While interest in learning objects and repositories continues, they have not seen the large-scale uptake that many predicted. Barriers to the success of content reuse were identified as the granularity of the objects, the ownership attached to the different levels of the original design and possible reinterpretations (Laurillard & McAndrew, 2003). The Learning Design specification (IMS, 2003) seeks to provide a means of reusing the pedagogy, or design, of a learning activity, and not just its content. Koper & Olivier (2004) suggest that Learning Design (LD) can be used as a means of representing and encoding learning materials, and this is especially suited to the elearning context while neutral to the pedagogy that is being applied. This may go some way to addressing some of the barriers to uptake found in a purely content-centric view of reuse, embodied in the learning objects paradigm.

As well as reusing content and design, it makes financial sense to reuse software components in the development of larger systems. A related motivation is the convenience afforded by reusing existing components that have already been developed and tested, instead of creating each one from scratch. The rise and acceptance of open source software developments has also suggested a third motivation, namely that of quality. By allowing components to be reused in different contexts they are improved or adapted by a community of users, to become increasingly robust.

Within the educational specifications area the initial focus was also on the reuse of content, with the resulting standards providing means of describing resources (metadata) and structures of resources (content packaging). More recently the focus has shifted towards interoperability of tools and services, as evidenced by the initiation of a Tools Interoperability Specification by IMS. However, beyond the generic web services standards, this is still an immature area with few robust and reliable standards that can be used.

The attention on tool interoperability has potential impact in the Virtual Learning Environment (VLE) sector, as educators begin to consider component VLEs comprised of a number of best of breed components, instead of the more integrated, monolithic systems offered commercially. The viability of such component VLEs has been raised by recent developments which seek to specify a generic, standards-based approach to VLEs, often focused around open-source systems. These include the SAKAI initiative in the US and the JISC service oriented architecture in the UK. The SAKAI project (http://www.sakaiproject.org), aims to deliver the following all as open source:

> "The products of this project will include an Enterprise Services-based Portal, a complete Course Management System with sophisticated assessment tools, a Research Support Collaboration System, a Workflow Engine, and a Technology Portability Profile as a clear standard for writing future tools that can extend this core set of educational applications."

The JISC framework (Wilson et al., 2004) outlines the benefits and approach for adopting a service oriented architecture, which can be seen as a means of viewing the integration of systems:

> "When we embark on this kind of analysis, identifying the parts of the MLE at a more granular level than monolithic systems, then we eventually end up with a *framework* of service descriptions. We are no longer interested so much in replicating data between large systems, but instead focus on what kinds of services are needed in the overall architecture to provide certain kinds of behaviour from applications."

Such an approach to services and tools is especially relevant to a Learning Design perspective. If the reuse of learning designs is to be realized, then it is likely to be because they meet the three main motivations for reuse set out earlier. They provide savings, can be more convenient than creating from scratch and offer quality benefits. Such learning designs are likely to be reasonably complex and pedagogically rich, since relatively simple ones can be easily created, thus reducing the benefits of reuse. This complexity of structure will often lead to a requirement for the use of a range of tools and services. Currently only email, conference and search are specified in the Learning Design guidelines. In order for complex designs to be created a greater range of services needs to be described, along with the provision for adding to these.

If learning designs are to be reusable however, they need to remain neutral in terms of requiring specific tools. The service approach therefore holds great attraction for the Learning Design community, as environments configured in this way have a greater potential to accommodate a Learning Design approach by calling on specific instances of services.

In order to realize this, three factors need to be in place:

1. Generic descriptions of services that a learning design can interpret in order to create complex pathways through material. For example, all bulletin boards perform the same sorts of functions. By describing these, a design that utilizes a bulletin board for an online debate with different roles (e.g. proponent, opposer, scribe etc.) can be realized.
2. A methodology for describing these services so that new ones can be added. This needs to encompass the means by which services are described, how LD recognizes these and how the description or consensus about a description is arrived at.
3. Tools, services and environments that are amenable to such an approach. This will include being able to expose the main functions of a tool, for example through open APIs or web services.

However, creating a generic service driven architecture is not easy. Despite much of the discussion surrounding this approach, there are few successful implementations. The Tasmanian LEAP project is a rare example (LeAP, 2004) which uses a service oriented approach to create a flexible VLE:

> "The project has guiding principles of interoperability and the use of standards for data and infrastructure. The preferred application architecture model uses a "service based infrastructure" approach. The reality is that the diversity of products within the educational computing environment makes it impossible to adopt a single approach to application architecture. LeAP considers it good practice to use existing services and create new services as application development progresses."

This may simply be a reflection of the relative immaturity of this approach. SAKAI is a relatively new consortium and have given themselves a tight timescale to deliver the first version of their vision. However, the lack of large-scale robust systems deploying generic service descriptions may also point to more fundamental problems, and maybe it remains an attractive theoretical construct that is difficult to realize in practical terms.

The question facing those working in this field then is to what extent a generic service description approach is achievable, and practical? If it is realizable then there are important implications for elearning, since it allows best of breed environments to be developed. As Wilbert Kraan of CETIS (2004) comments:

> "It is becoming clear that common e-learning activities … can't really be done by one application that has little or no knowledge of everything else on the network or the wider internet. It's also becoming clearer that a single system that tries to combine all such functions is unlikely to do all of them equally well. Furthermore, one size systems do not necessarily fit all institutions."

However, the success of a generic services approach has wider software applications also. A generic service approach has the ability to influence what happens across a range of domains. In his book *Darwin's Dangerous Idea* Dennet (1995) proposes the notion of a universal acid which is so strong no container can hold it. He uses this analogy for the theory of evolution, demonstrating how it was not refined to biology alone. In a more limited sense, a generic service approach has this ability also, since it demonstrates that rich environments can be created from components that are not tightly integrated, and can be decoupled easily. The analogy of Dennet's universal acid is also applicable in that he argued that evolution demonstrated how complex and rich variation in living species could be derived from relatively simple processes, in essence that relatively simple algorithms can produce complex behaviour. The generic services approach similarly claims that complex and rich environments can be developed from simple service descriptions, without the need for programming complexity.

The opposing view is that while generic service descriptions are appealing from a theoretical and architectural perspective, they are impractical and inefficient. For example, in developing the LAMS tool, Dalziel (2005) suggests that in order to create tools that are meaningful from a Learning Design perspective – 'Learning Design aware' tools as he terms them – it was more practical to build the tools from scratch than reengineer existing ones. LAMS provides the educational author with a number of tools, such as voting, discussion, quizzes, etc. Each of these components was built specifically for the LAMS editor, so that the sequencing of activities that LAMS sets out can be realized. Dalziel makes the distinction between 'rich' and 'minimal' component integration, arguing that for the necessary control and flow through a Learning Design driven environment, rich integration is the better option:

> "Richly integrated components, as demonstrated in LAMS, are technically more challenging to achieve initially, but provides a seamless, integrated environment for both teachers and learners, with better potential for reliable quality of service."

A generic description will always offer less functionality than a complete, bespoke service description and so much of the richness of individual programs is lost. In addition the brokering of services required in such an approach leads to inefficient data handling and needless additional steps in the transaction path.

The SLeD project

The SLeD project (http://sled.open.ac.uk) aimed to address some of these issues. The project was funded as part of the JISC Elearning Framework programme (http://www.elframework.org/), which is itself constructed around the concept of a service oriented architecture. The project was a collaboration between the UK Open University (UKOU) and the Open University of the Netherlands (OUNL).

The specific objectives of the project are given below, but the more general purpose was to extend the tools available to the Learning Design community and also to further develop our own understanding of how a Learning Design approach might be practically realized within an institution. For both the UKOU and the OUNL, Learning Design has three possible benefits:

1. As a means of describing course design in a format that can be shared between academics and technical staff.
2. As an audit trail of the design decisions, which can be reviewed as part of any quality assurance process.
3. As a means of providing structure and support to students and tutors via the delivery mechanism. This is particularly acute when students are studying at a distance and attempting complicated activities.

The SLeD project can thus be seen as an attempt to address at least part of this growing institutional interest in Learning Design (McAndrew & Weller, 2005).

The initial project was focused on upgrading the OUNL CopperCore Learning Design engine (http://www.coppercore.org/), to deal with level B learning designs, become SOAP compliant that it could utilize a web services approach and to develop a Learning Design player. The specific objectives were:

1. Upgrade CopperCore Learning Design engine to be SOAP compliant.
2. Upgrade CopperCore to be IMS LD level B/C compliant.
3. Produce a service based player system (SLeD) linked to the CopperCore engine.
4. Create ancillary services for the player to control rendering and environment information.
5. Enrich understanding of learning design in the context of course production and evaluate Learning Design as a method of supporting online course development.
6. Create a Wizard and guidelines for authoring.

A Learning Design player was already included in the CopperCore package, but the rationale for this project was to separate out the player functionality from the underlying engine. This was partly realized within the existing CopperCore Engine but the focus of the JISC-funded project was to enhance the ways in which the CopperCore Engine could be used by adopting the web services approach. So, communication between the player and engine used web services and additional end user tools such as search and conference systems were coded to allow web services. This approach proved useful in extending the reach of the CopperCore system by allowing others to take advantage of the changes to CopperCore, for example the Reload system (http://www.reload.ac.uk) is now able to prepare a 'dummy run' which can be validated and tested using the same communication routes with CopperCore.

This project coincided with the OUNL roadmap for enhancing CopperCore capabilities to support the higher levels of LD. Level A support means that a complete planned design can be presented provided its structure can be pre-determined for each role within it. This allows for fairly linear learning designs, but not more complex ones. Supporting level B means that designs can include properties and conditions that determine progress in a more dynamic way. These changes led to the release of an updated reference player to demonstrate the new features and release of a separately developed player SLeD to demonstrate new ways to communicate with the engine and provide a path for less constrained development of the player system. By separating out the player and the underlying engine it maintains a 'clean' architecture that embodies the modular principles of the initial CopperCore project.

Initial work was successful in integrating two types of conference (forums) into the SLeD player, and similarly two separate instantiations of a search function. The two forums were OpenText's FirstClass system, and the inhouse Knowledge Network at the OUUK. The two search tools were Google, and the Knowledge Network again. The integration of these services demonstrated that both commercial and open systems could be called from the player, giving users a wide choice as to the actual implementation of any service they prefer.

One objective that was not met was the development of a wizard-based approach to developing LDs, although some initial work was begun in this area. This is currently being developed in a separate JISC funded demonstrator project.

A second project was initiated in April 2005, with further funding from JISC. The aim was to build on the success of the first project, particularly in extending and formalizing the approach for integrating services while maintaining the architectural integrity of the system, and also to continue the development of the CopperCore engine. There were three main deliverables for this project:

- Upgrading of CopperCore to integrate QTI calls in LD packages
- Development of a technical methodology for integrating service calls in LD
- Demonstration of this methodology with an interface to an ePortfolio tool

The project sought to significantly extend the initial SLeD work in two key areas. Firstly, although Learning Design had generated a lot of interest and enthusiasm, it was now at the stage where it needed to be put into practical use. The integration of assessment services into the learning designs was seen as a crucial factor in this. By upgrading CopperCore to validate IMS LD packages containing QTI this significant advance could be realized through a recognized core Learning Design system.

The second key area was to address the area of current weakness in the Learning Design specification, namely the paucity of services which it can reference. The work in the SLeD project began to address this by developing a generic method for calling search and conferencing services. The second phase of the project further developed this approach and formalized it, to create a toolkit for service integration. The proposed approach was to use the QTI work as a test bed to develop a generic technical methodology for integrating services.

Through this project it was hoped that an answer, or at least further insight, would be gained to the question as to which of the two views outlined above regarding generic service descriptions was correct. Is it the universal acid or the impractical concept?

SLeD Architecture

The experience of implementing bulletin boards in the initial SLeD project, and the work in integrating QTI calls led the project team to devise the architecture shown in figure 1.

The shading in the diagram represents the work of the second SLeD project, in extending the work undertaken in the initial project.

In this model the generic service descriptions are housed in the services broker. A learning design can also be delivered with other valid packages, for example QTI files, inside a single content package. The IMS LD

Content package contains and defines all data for all the required services. The Learning Design engine (in our case CopperCore) is responsible for the validation of the IMS CP package and the correct publication of it to the different services. The service dispatcher interprets the type of resource requested by the player and acts upon it. It contains the logic for synchronizing the properties and calling the underlying services. In the case of the SLeD project the Learning Design Engine will be CopperCore, and the player is SLeD, but in this open architecture these could both be replaced. Similarly, the QTI engine should be any standards compliant engine. Other services might include forums (or bulletin boards), eportfolios, search, email, etc.

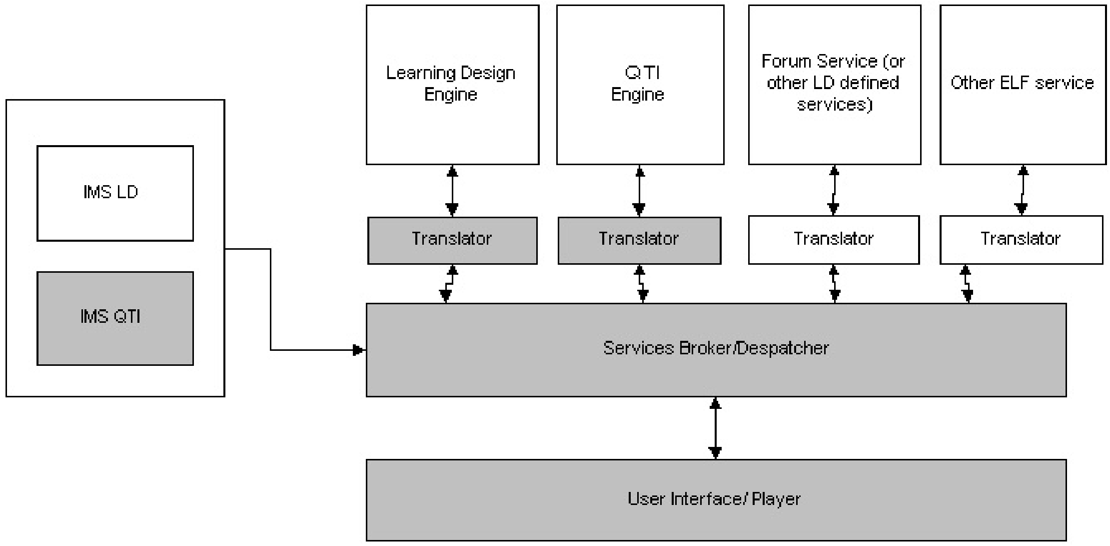

Figure 1. Structure of SLeD

The player handles the display, coordination and user interface of the services to the user.

Although generic service descriptions are stored in the broker, unless each individual service is set up to pass information back in exactly the required format, the generic descriptions will not be able to correctly handle the data. It is therefore necessary to have a small piece of application specific code that in effect acts as a translator between the application in question, and the generic service description.

Essentially the translators provide the interface between the broker and the actual service. The purpose of the translator is to match up the method calls made by the broker to the methods provided by the service provider, which may be internal java, web services, etc. A simple example would be that the APIS QTI service (http://ford.ces.strath.ac.uk/APIS/) might have a method 'getQuestion', but another QTI service might have called a method (which serves the same purpose) 'returnQuestion'.

Each of the translators is an individual java library (.jar file), not just a separate class within the application, as having separate files means that if someone wishes to use a different application for an existing service, then they simply replace the translator file.

Another advantage of having separate java libraries is that different installations can use different combinations of services, but still maintain portability of the translators. If everything (broker & connections to services) is bound up into a single library, it would require more work to switch between service providers and would greatly reduce the portability of the components.

The amount of coding required for a translator is relatively small, an example for a search translator which uses the UKOU's Knowledge Network (an internal document management system) is given below:

```
public String doSearch(String SearchTerm){
    String ret = "";
    try {
    // KN Search
      String endpoint = searchConfig.getSearchWebServiceURL();
      Service service = new Service();
      Call call = (Call) service.createCall();
      call.setTargetEndpointAddress(new java.net.URL(endpoint));
      call.setOperationName(new QName("http://webservice", "KNSearch"));
```

```
      Object[] inParams = new Object[1];
      inParams[0] = new String(SearchTerm);
      java.lang.Object response = call.invoke(inParams);
      ret = formatKNResults(response.toString());
      service = null;

    }
    catch (Exception e) {
      ret = "Error in doSearch: " + e.toString();
    }
    return ret;
}

private String formatKNResults(String in){
    String output = xmlDeclaration + "<search>";
    try {
      SAXBuilder builder = new SAXBuilder();
      Document inXML = builder.build(new StringReader(in));
      List runList = inXML.getRootElement().getChildren("result");
      for (int i = 0; i < runList.size(); i++) {
        Element temp = (Element) runList.get(i);
        output = output + "<result>";
        output = output + "<rank>" + temp.getChild("rank").getText() + "</rank>";
        output = output + "<title>" + temp.getChild("title").getText() +
"</title>";
        output = output + "<url>" + temp.getChild("url").getText().replaceAll("&",
"&amp;") + "</url>";
        output = output + "</result>";
      }
      output = output + "</search>";
    }
    catch (Exception e) {
      return e.toString();
    }
    return output;
  }
```

If we compare this with a translator for a search in Google, the type of difference required between the two applications can be seen:

```
public String doSearch(String SearchTerm){
    GoogleSearch search = new GoogleSearch();
// Set mandatory attributes
    search.setKey(searchConfig.getGoogleApiKey());
    search.setQueryString(SearchTerm);
    System.out.println("here1");
// Set optional attributes
    search.setSafeSearch(true);
    search.setProxyHost(searchConfig.getProxyHost());
    search.setProxyPort(Integer.parseInt(searchConfig.getProxyPort()));
// Invoke the actual search
    return formatGoogleResults(search.doSearch());
  }

private String formatGoogleResults(GoogleSearchResult in){
    String output = "<?xml version=\"1.0\" encoding=\"UTF-8\"?><search>";
    try {
      GoogleSearchResultElement[] results = in.getResultElements();
      for (int i = 0; i < results.length; i++) {
        output = output + "<result>";
        output = output + "<rank>" + (i + 1) + "</rank>";
        output = output + "<title>" + results[i].getTitle() + "</title>";
        output = output + "<url>" + results[i].getURL().replaceAll("&", "&amp;") +
"</url>";
        output = output + "</result>";
      }
      output = output + "</search>";
    }
```

```
    catch (Exception e) {
      return e.toString();
    }
    return output;
  }
```

While there are considerable similarities, the specific calls and structure for each application need to be translated in to the generic service description. The public method descriptions (method name, input and output parameters and types) must remain the same, whichever actual service is being connected to, since these are the methods the broker will connect to; so these represent the generic service descriptions. In the example code, the broker is expecting the search results back in a particular XML format. However, it is inside these methods where the code becomes specific for the actual service used. For the Knowledge Network search, the service is called using a web service call, the results from this service are then transformed to the XML format the broker is expecting (using the private method formatKNResults). The Google search differs in that it is called using a Java API, but again the search results need to be transformed to the XML format the broker is expecting (using formatGoogleResults). So the type of API the external service uses is not important - Java, web service, direct database connection etc - providing the translator can convert the call from the broker to the required call to the external service, and the results from the external service can be converted back to the format the broker is expecting.

For existing services then it is simply a matter of creating a new translator for any specific application. Obviously if the translator has already been developed for that application then any other user can simply adopt it, so for common applications a library will quickly be established that removes the necessity for any development.

However, for new services, for example eportfolio, where there is no current generic service description the process is a little more complicated. Firstly it is necessary to develop the generic service description. This can only be achieved by a survey of different instances of that service to determine a generic set of functions. These need to be coded in a manner that a learning design can utilize. It is then necessary for the generic service description to be incorporated in to the service broker so it can coordinate the services.

This is undoubtedly more work, but it demonstrates the benefits of the open architecture. It is likely that multiple users will wish to integrate a service, and many will be using different applications to realize that service. Instead of each of these users creating an application specific interface a single generic description can be developed, and then only the relatively small task of creating the translators falls to each of the separate parties.

Discussion

In our work we sought to provide a usable Learning Design system by further developing the successful CopperCore engine and the initial work done on the SLeD player. We also sought to gain further insights into the more general issue as to the practicality of the generic service approach, as this had generated a good deal of interest but with few practical examples.

The architecture and methodology we developed represents a compromise between the pure generic service solution and the application specific approach. The use of generic service descriptions by the service broker creates an open architecture where any service can be replaced and added. However, it still requires an element of application-specific coding in the form of the translators. This could be viewed as a temporary measure, since if all the instances of a particular service complied with the generic service description there would be no need for the translators. Such compliance remains unlikely, and so the method outlined here represents a reasonable compromise between the abstract ideal and the market reality.
Although this paper has offered a potential model for incorporating the generic service approach into the current environment, there remain a number of unanswered questions. Firstly, we have not yet determined the efficiency of such a system and whether there is a significant load in transfer of data. Secondly, and perhaps more significantly, we have not explored the limitations of generic service approach. While it is possible to derive a list of generic functions from a range of tools providing the same service, by necessity this ignores differences between them. Thus any particular richness or subtle nuances of a specific program will be lost through this approach since only the generic services are required. This may be the price that is paid for any reusability. A specific instance can always provide a richer example than one which is created to be reused in multiple contexts. The issue is whether that additional richness is worth the cost.

Further work is required to extend the range of services that can be included, and thus to provide a more robust test of the methodology. In addition there are issues which this project did not address, for instance the user interface of different systems, and the extent to which the player, or the initiating service controls this. While it may be possible for the player to offer a uniform user interface by simply taking data in a web services format, this underestimates the significance of how the interface affects the user's behaviour in the originating service. It may be that a software system with a different interface simply does not make sense to the user, or more likely, that it subtly alters their interaction with the system, so that users of the original program, and users of the Learning Design player version behave differently. There is still comparatively little work on the affordances of software and the subtle influences this can have on how a user interacts with a system, but in the general shift towards service oriented architectures with their emphasis on underlying system functionality, it is important we do not overlook the nuances of interface design.

If we return to the fundamental question of this paper, we asked whether the generic service approach had the capability to be a form of universal acid, or whether it was really more of an academic construct destined never to remain the focus of an interested minority. The SLeD project has not provided us with a definitive answer it seems. The architecture and model suggests a way in which the approach could be realized, but the necessity of the translator elements compromises the purity of the solution to an extent, although it also offers a means of bridging the gap between the two viewpoints.

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Usability of a Runtime Environment for the Use of IMS Learning Design in Mixed Mode Higher Education

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ABSTRACT

Starting from the first public draft of IMS Learning Design in November 2002, a research project at the Catholic University Eichstaett-Ingolstadt in Germany was dedicated to the conceptual examination and empirical review of IMS Learning Design Level A. A prototypical runtime environment called 'lab005' was developed. It was built based on Moodle, a web-based, open source course management system. Development and use of the lab005 runtime environment were intensely evaluated. Several university courses provided a use case for the empirical review of IMS Learning Design, which covered mainly two issues: firstly, whether IMS Learning Design can be used to support mixed mode learning scenarios (use for blended learning), and secondly, how users interact in learning situations with a learning environment for IMS Learning Design (usability in terms of human-computer interaction). This article gives an overview of the web-based learning environment lab005, its underlying concepts and outcomes of experimental use and evaluation. Though limited in scope, the successful implementation of IMS Learning Design in higher education proves the possibility to support mixed mode learning scenarios. Key concepts for the graphical user interface of lab005 are illustrated in order to give insights into the use of IMS Learning Design in mixed mode learning scenarios. Details in the results of evaluation concern the classification of learning objects, the use of environment as an element in IMS Learning Design and challenges in the application with face-to-face situations and with real life objects in classroom learning scenarios.

Keywords

Blended Learning, Learning Environment, IMS Learning Design in Practice, Runtime Environment for IMS Learning Design, Moodle

Introduction

When IMS Learning Design was released as a final specification in February 2003, neither runtime environments nor authoring systems were existent. Some exemplary learning scenarios, which could serve as proof of concept, were described in the IMS Learning Design Best Practice and Implementation Guide (Koper et al., 2003a). But successful and practical application of the core concepts in single learning scenarios or on a large scale was a task still to be fulfilled. Today, initial information systems, appropriate reference architectures as well as some examples of implementation in practice are at hand (Koper & Tattersall, 2005).

Yet, in the very beginning, IMS Learning Design was a future concept to be conceptually examined and empirically tested. The core concepts of IMS Learning Design had been taken from the Educational Modelling Language (EML) of the Open University of the Netherlands (Koper, 2001). Within the discussion on reuse and standardisation, they offered a remarkable shift from content to process and thus to learner-centred approaches like situated learning and social-constructivist learning – towards computer supported cooperative learning (CSCL) scenarios as well as towards the integration of web-based self-study with traditional classroom teaching (blended learning), and away from the paradigm of content-based knowledge delivery. However, the application of these concepts in practice still had to be proved.

Background

Starting from the first public draft in November 2002, a research project at the Catholic University Eichstaett-Ingolstadt in Germany was dedicated to the conceptual examination and empirical review of IMS Learning Design Level A. The objective of this research project was to evaluate the scope of IMS Learning Design from a theoretical perspective based on specific German approaches towards teaching and learning. Several courses at the Catholic University Eichstaett-Ingolstadt provided a use case for this evaluation. There was no intention to fully implement IMS Learning Design at university; practical use merely aimed to test it within these mixed mode courses. Two main issues were covered by this empirical review: Firstly, can IMS Learning Design be used to support mixed mode learning scenarios (blended learning)? Secondly, how do users in learning situations interact with a learning environment for IMS Learning Design in terms of usability for human-computer interaction?

As neither runtime environments nor authoring systems existed, at least a runtime environment for the use of IMS Learning Design in teaching-learning scenarios was needed. In order to facilitate the creation and running of mixed mode units of learning in higher education, a prototypical runtime environment called 'lab005' was developed. As a graphical user interface to be used in classroom teaching as well as for self-study, this web-based learning environment was built extending Moodle, an open source course management system (http://www.moodle.org and Dougiamas & Taylor, 2002). While the web-based learning environment lab005 was developed, units of learning had to be designed conformant to IMS Learning Design. By now, seven university courses (and an exemplary unit of learning for use in usability tests) have been developed and are operated on a regular basis.

The specification IMS Learning Design starts from the concept of 'units of learning'. A unit of learning is to be considered as a single unit that is designed towards one or more learning objectives. Hence, a unit of learning is a self-contained period in a teaching-learning process, limited in time and dedicated to a certain issue of a subject that is studied (Koper, 2001). For practical use, we decided that a university course spanning a whole term covers a number of units of learning (i.e. plays in IMS Learning Design). Their sequence resembles chapters in the course. Within the weekly organisation of university courses, each may span one or several weeks, depending on learning objectives, subject matter and arrangement of the teaching-learning process.

Development and use of the runtime environment lab005 was intensely evaluated from the perspective of users in mixed mode learning scenarios, both staff and learners. The evaluation did not intend to prove advantages and disadvantages of one or another pedagogical approach. A main objective of the IMS Learning Design specification is to be pedagogically flexible (Koper et al., 2003b), hence to be both rich and neutral in an educational sense. Pedagogical information should be enclosed and expressed in units of learning, but instructional designers must not be restricted to specific pedagogical models. For that reason, no specific pedagogical approaches were taken for the conceptual examination and empirical review of IMS Learning Design in the observed university courses. On the contrary, the regular educational settings of these courses were taken as a proof for the scope of IMS Learning Design. The courses were weekly seminars that combined lecture, discussion, group work and hands-on experience with self-study for preparation and research. According to topics of the courses case studies, problem-oriented learning and learning assignments were used to structure the teaching-learning process. In doing so, the emphasis on process instead of content and on learning activities as a core concept led to a certain shift in the design of the courses.

Intentions and Scope

Rather than proving advantages or disadvantages of individual pedagogical approaches, development and experimental use of the web-based learning environment lab005 was dedicated to the evaluation of core concepts of IMS Learning Design. The main focus was given to the practical use of IMS Learning Design in teaching-learning scenarios, and thus to the realisation and application of units of learning conformant to IMS Learning Design in the context of normal courses at university. The following interpretation of the core concepts served as hypotheses for the evaluation:

- Learning activities and supporting activities are adequate concepts to describe a teaching-learning process.
- In order to describe a teaching-learning process, learning activities and supporting activities can be organised in a hierarchical and sequential structure.
- A plan for a process of teaching and learning can be organised separately from resources for teaching and learning.
- A classification of resources for teaching and learning enhances a learner's comprehension of the teaching-learning process.
- Through the description of the teaching-learning process, traditional classroom teaching can be integrated with web-based self-study, in order to support mixed mode learning scenarios.

These aspects reflect two questions covered by the empirical review: Can IMS Learning Design be used to support mixed mode learning scenarios? How do users in learning situations interact with a learning environment for IMS Learning Design in terms of usability?

Resources for implementation were limited, so lab005 was developed as a prototypical runtime environment. It was built towards the requirements of use in the observed university courses and the purposes of evaluation. Hence, only a subset of Level A from the specification IMS Learning Design was implemented. This subset focussed on learning activities and supporting activities, their organisation in hierarchical-sequential structures and the delivery of resources for learning, such as learning objects and services. Other concepts, like the concept of 'on completion' in Level A (Koper et al., 2003b), were not implemented. This limited scope provided the possibility to react rapidly to user requirements, which were formatively evaluated as feedback for improvement of the web-based learning environment.

There were no authoring features implemented. Units of learning were created using standard applications, especially for editing and validating the XML-files needed for IMS Learning Design. Using an advanced XML-editor proved to be quite efficient though editing learning designs in pure XML is a task that requires profound understanding of both XML and the specification.

Even if limited in scope, the successful implementation of IMS Learning Design in higher education proves the core concepts of IMS Learning Design, especially the possibility to support mixed mode learning scenarios (Klebl, 2005).

Building a Prototypical Runtime Environment: lab005

Various functions, which are essential for web-based learning environments, are independent from IMS Learning Design: features like management and delivery of resources for learning, management of courses and users including authentication and access and, finally, web-based communication services are provided by various learning management systems. Therefore, the idea to extend an existing learning management system for an experimental use of IMS Learning Design suggested itself. Obviously, an open source system offered best opportunities for extension. Moodle, a web-based, open source course management system was chosen as a learning management system that provided ample functions for management of resources for learning, users and courses. lab005 was built based on Moodle as an extension in order to enable Moodle to act as a prototypical runtime environment for IMS Learning Design Level A. So lab005 basically adds two features to Moodle: firstly, course structures conformant to IMS Learning Design Level A and secondly, a presentation level for compatible units of learning. As stated above, this extension to Moodle was limited in scope and implemented only a subset of Level A.

The following part of the article describes the prototypical runtime environment lab005, which is used to run mixed mode courses at university. Relevant modifications to the Moodle open source course management system and the approach for usability evaluation are described in brief. An account of viable concepts for the graphical user interface completes this section.

Starting from Moodle

Due to limited resources for development and operation, the choice for the development of lab005 was limited to web-based systems based on PHP and MySQL. A brief evaluation of open source learning management systems available in February 2003 resulted in a decision for Moodle (at that time version 1.0.8.1).

In Moodle, learning objects and services are implemented as 'modules' (such as resource, assignment, chat, forum, journal or quiz). Instances of modules, i.e. learning objects and services used in a course, are inserted within sections that form the course structure. Hence, resources for learning can be arranged to organise the teaching-learning process according to predefined course formats. Course formats are templates for course structures. Default course formats in Moodle are 'topic format', 'weekly format' and 'social format'. Thus instances of modules, i.e. learning objects and services, can be arranged in relation to topics according to weekly sessions or around discussion forums.

Functions for course formats are implemented separately from functions for modules. This offers the possibility to create new course formats for Moodle. Thus, a new course format called 'imsld' was implemented for lab005. This new course format provides functions to use Moodle as a runtime environment for units of learning compliant to IMS Learning Design Level A.

In this course format, resources for learning can be arranged according to the above named core concepts of IMS Learning Design. The required course structure for lab005 is described in the file `imsmanifest.xml`, which is conformant to XML-schemas for IMS Content Packaging and IMS Learning Design Level A. Resources are referenced from this file using the identifier for instances of modules in Moodle, which is a consecutive number for all instances of learning objects and services.

According to the IMS Learning Design Level A specification, the course structure is built from plays, acts, activity structures and activities, where the latter two are assigned to roles through role-parts. All resources for learning (i.e. instances of modules in Moodle) are inserted within environments (in terms of IMS Learning Design), which are connected to activities. In this way, it is possible to edit the file `imsmanifest.xml` in an XML-editor and thus create the learning design with learning and supporting activities, which are organised in plays, acts, and activity structures respectively and with associated environments.

The graphical user interface of the web-based learning environment lab005 offers different views of the course structure (see details below), depending on role, progress in the teaching-learning process and user's choice. For these views, the information in the file `imsmanifest.xml` for a running unit of learning is processed (on the server side through XSL transformations and access to the XML-DOM) and presented to both learners and teaching staff in the web-based learning environment lab005. In order to integrate different views on the course structure conformant to IMS Learning Design well into the whole graphical user interface, a unique presentation level was also developed. For that, Moodle offers the possibility to integrate custom themes. Figure 1 shows the resulting architecture for the extension of Moodle to lab005, with extended components marked in grey.

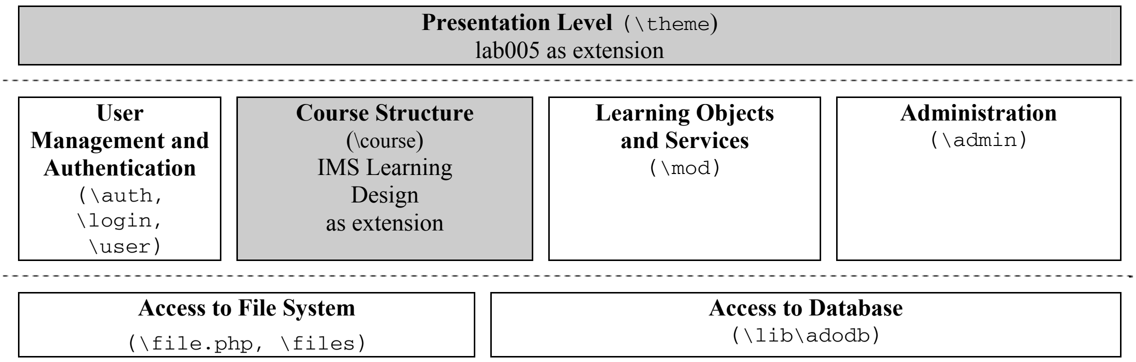

Figure 1. Modification of Moodle for prototypical runtime environment of IMS Learning Design

A Formative Approach to Usability Evaluation

IMS Learning Design is designed as a framework for a comprehensive description of the teaching-learning process consisting mainly of an information model and the binding to XML. Instructional designers may use it as a notation system for creating learning scenarios in pure XML or with specific editors. Nevertheless, while operating units of learning conformant to IMS Learning Design, learners and teaching staff will never encounter any XML; they will use a graphical user interface and normally interact with a web-based learning environment based on IMS Learning Design. So in practical use, issues of suitability, completeness and scope of a specification like IMS Learning Design can be examined only through the usability of the user interface for an information system. Usability of a runtime environment for IMS Learning Design applied to units of learning can reveal aspects of suitability, completeness and scope of this specification. As stated in ISO 9241-11, usability relates to effectiveness, efficiency and satisfaction in the use of a product regarding a specified context, specified users and a specified goal (Çakir, 2000). Hence, in the context of courses at university, students (and teaching staff) use a web-based learning environment for IMS Learning Design in order to study and learn.

The representation of the course structure was designed to reveal underlying concepts of IMS Learning Design in a meaningful manner for both learners and teaching staff. Through formative evaluation, user requirements were observed and analysed. A formative approach was chosen for usability evaluation, in order to understand strengths and challenges of both IMS Learning Design and its tentative implementation in lab005. Thus, the formative evaluation provided rapid feedback for improvement of the web-based learning environment. During an iterative process (development on the one side and use in practice on the other side) four different versions of lab005 were reviewed in usability tests with students and usability workshops with experts.

In usability testing, qualitative and quantitative methods were combined. In a quantitative approach, each of the four versions of the graphical user interface were evaluated in a usability test. In these usability tests, which lasted two hours, students first completed an exemplary unit of learning and then rated aspects of usability with a questionnaire. This questionnaire was adopted from the IsoMetrics usability inventory (Hamborg, 2002) and adequately modified. For the qualitative approach, experts were invited for usability workshops lasting half a day. They were asked to examine and discuss use and usability of the web-based learning environment based on heuristic criteria, which were taken from Rolf Molich and Jakob Nielsen (developed in 1990, retrieved in a German translation, Schweibenz & Thissen, 2003). The usability workshops were scheduled during the development of an enhanced version following a qualitative usability test with students of the former version. So both results from the test of the former version and the outline for the next, enhanced version were able to be discussed. A comprehensive account of the evaluation can be found in Klebl (2005).

A major improvement in usability was noted for evolving key concepts of the graphical user interface from the second to the third of all four reviewed versions of lab005. This improvement was especially evident for two dimensions of usability:

- Firstly, the dimension 'user control' improved significantly comparing the latter two versions to the second version. Usability aspects belonging to 'user control' include simple navigation and ease of access to functions and resources.
- Secondly, the dimension 'immediate orientation', which gathers aspects of usability concerning the comprehension of the outline for a unit of learning, showed improvement of the latter two versions compared to the second version, significantly for the fourth compared to the second.

Hence, some features and characteristics in the graphical user interface of the latter two versions of lab005 are considered as appropriate concepts for implementing IMS Learning Design in a runtime environment. As viable key concepts, the main characteristics of the latter two versions are described in the next section. In the subsequent section, some relevant conclusions will be drawn from these concepts regarding the use of IMS Learning Design, especially in connection with mixed mode learning scenarios.

Viable Concepts for the Graphical User Interface

In this section, key concepts for presenting units of learning in the graphical user interface of lab005 are illustrated in order to give insights to the use of IMS Learning Design in mixed mode learning scenarios. These concepts concern the representation of core concepts in IMS Learning Design, including the representation of a hierarchical and sequential organisation of learning (and supporting) activities. Subsequently, the representation of both single activities and resources for learning is discussed. Finally, the question as to how progress in the teaching-learning process can be marked is examined.

Taxonomy and Sequencing in the Activity Tree

As in most runtime environments already implementing IMS Learning Design (e.g. the LD-player provided by CopperCore, Martens & Vogten, 2005), a tree view is used in lab005 to illustrate the plan for the teaching-learning process (see Figure 2). The aggregation of single activities within container elements such as activity structures, phases (in LD terms 'acts') and methods (in LD terms 'plays') to a teaching-learning process is represented by an activity tree, which is a central instrument for navigating a unit of learning.

A tree-based organisation of informational elements is very common to graphical user interfaces ranging from file systems to web-based information systems. A tree for the organisation of informational elements is comfortable and well known, but lacks a sense of process structure with subsequent, parallel and unordered elements. Especially activity structures, which allow both sequencing and choice for subordinate activities, must to be marked to indicate the flow of the teaching-learning process. Therefore, in lab005, sequenced activities (resp. sequenced subordinate activity structures) are linked with arrows [A], while activities for choice (or subordinate activity structures for choice) are identified by radio buttons, as indicated in the following screenshot.

The first versions of the graphical user interface of lab005 offered the entire activity tree for a course to the user: from root, i.e. the learning design itself, through acts, activity structures, activities and environments down to learning objects and services. As usability studies showed, an entire tree for a course is far too complex for comfortable navigation. In the latter versions, the activity tree was divided into three levels of details in aggregation, each of them serving a special purpose: Firstly, there is a view of the whole course, secondly a view of a unit of learning in the course (Figure 2), and thirdly a special view of a single learning (or supporting) activity (Figure 3).

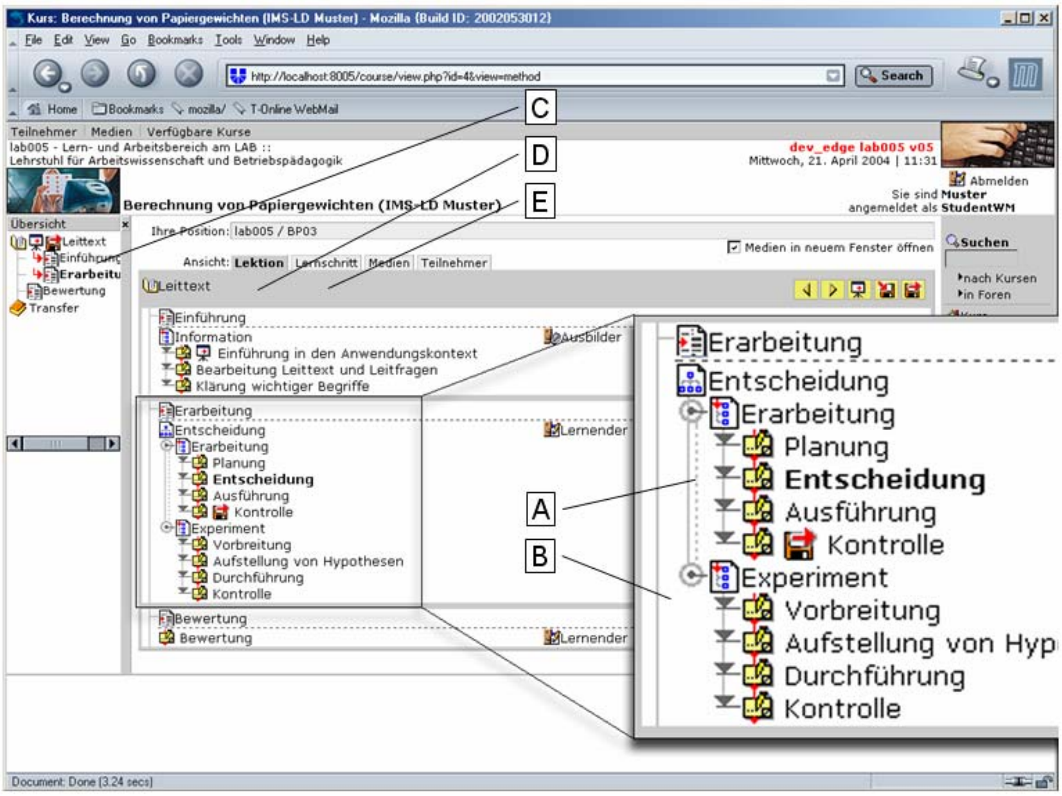

Figure 2. Screenshot of Activity Tree in lab005

- For an initial view of the whole course, a tree with two levels represents a number of units of learning [C]. Several units of learning (i.e. plays) are sequenced like chapters in a course spanning a whole term. A unit of learning may span one or several weeks within the weekly organisation of university courses. For practical reasons, the multiplicity of plays subordinate to a method element within a learning design was treated as a sequence of plays. In addition to this first level, symbolised by books, a second level shows phases within these chapters (i.e. 'acts' in LD terms). This outline for the whole course is found on the starting page for a course. Further on, this overview can be accessed at any page in a sidebar for quick navigation through the course.
- In addition to this overview for the whole course, an activity tree unfolds for a chapter when a user chooses a chapter or a tab in order to view the current chapter [D]. This activity tree displays phases (i.e. 'acts' in LD terms), activity structures and activities. In the latter versions of lab005 this view for a teaching-learning process was put on a card with a tab and did not include elements of the learning environment nor features for collapsing or expanding elements. Hence, structure and steps in the planned teaching-learning process are represented in a simple, comprehensive way.
- Thirdly, single activities can be chosen and a second tab [E] next to the tab for this view of a chapter allows a view of the current activity (Figure 3). In this way, individual learning (or supporting) activities are represented on a screen that becomes a cue-card for performing these activities.

These three levels of aggregation for the teaching-learning process provide the opportunity for a fast and comfortable information zoom. They lead a learner from the overview of the whole course down to a single activity that stands for a task that has to be fulfilled at a given moment in the teaching-learning process. As levels, they correspond with the given taxonomy of plays, acts (with role-parts), activity-structures and activities in IMS Learning Design.

Cue-Cards for Activities

In the latter versions of lab005, a special metaphor for both learning and supporting activities was introduced: The view for a single activity becomes a cue-card (Figure 3). The activity description is central to this screen

[A]. It is completed by a title [B], the title for the play to which this activity belongs [C] and by the role to which this activity is assigned [D]. This cue-card can be accessed through a second tab next to the chapter view tab. Whenever an activity is chosen, this cue-card is presented.

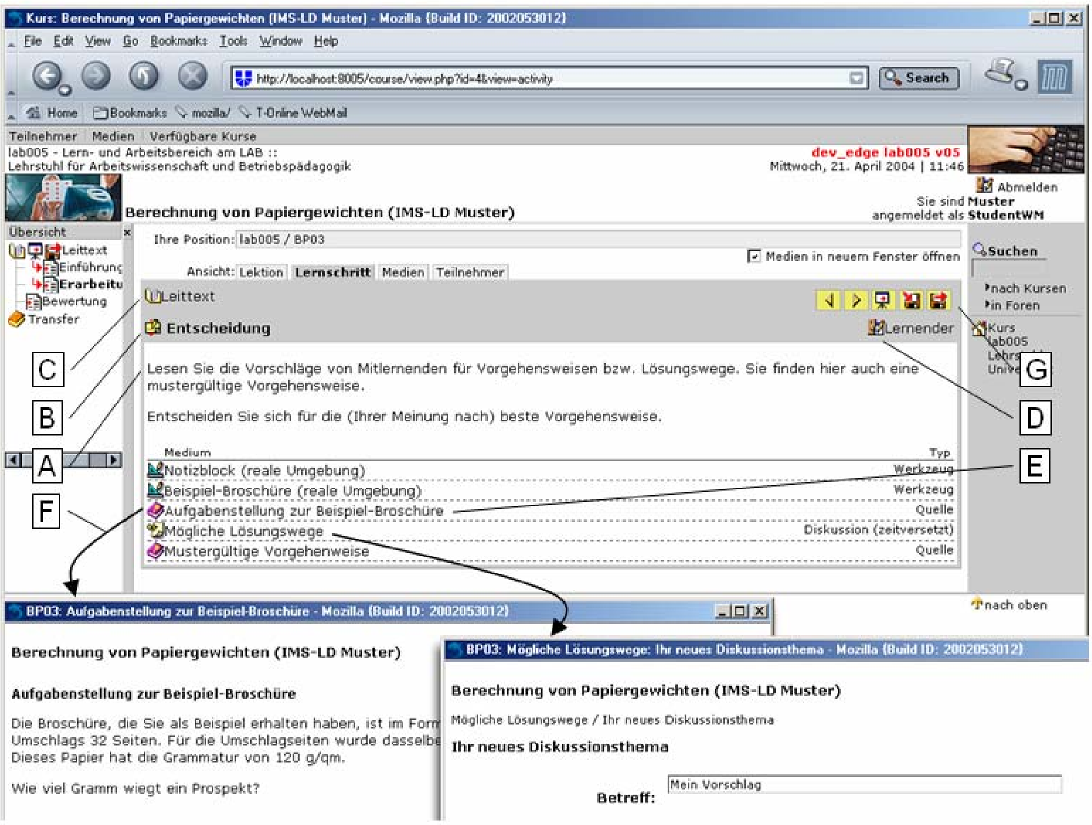

Figure 3. Screenshot of view of single activity in lab005

All elements in the learning environment that are linked to this single activity are listed below it [E]. Thus, both learning objects and services are directly at hand in order to perform a learning activity or supporting activity. They open into new web-browser windows – so they can be used in parallel [F].

A navigation tool [G] that allows browsing back and forth step by step using arrows as buttons is placed on the cue-card. Cue-cards for activities help to structure the process of teaching and learning. They are not meant to restrict activities of learners and interaction between learners and teaching staff. Neither are they used or perceived this way. They are employed as a helpful tool in structuring and comprehending complex interactions in teaching and learning.

List of Elements in the Learning Environment

In IMS Learning Design, learning environments (`<imsld:environment>`) are an important element to order and structure learning objects and services used in the teaching-learning process. Environments are container elements. Since they can be nested, they can be used to build a hierarchical organisation for learning objects and services. Learning objects and services cannot be assigned to activities directly, so learning environments serve as linking elements between activities and resources for learning. However, learning environments are not only linking elements. Instructional designers may use them to group learning objects and services into packages, in order to reuse these packages and to present them to the learner at a given step in the teaching-learning process.

As the specification suggests (Koper et al., 2003b), the hierarchical organisation of learning objects and services is to be presented to the learner. The LD-player provided by CopperCore (Martens & Vogten, 2005) provides an environment tree that represents all given elements of the learning environment at a given step in the teaching-learning process.

From the viewpoint of a learner, this grouping increases the complexity and appears to be needless. A single learning or supporting activity (itself a leaf node of a hierarchical and sequenced organisation of the teaching-learning process) is considered as the smallest meaningful entity in the unit of learning. Starting from this entity, a learner expects simple and parallel access to all learning objects and services needed to perform an activity. This notion may be enhanced through the metaphor of a cue-card for activities, where these are clearly marked as the smallest entity in the process of teaching and learning. Hence, in the latter versions of lab005 elements in the learning environment are presented in simple, table-like lists. These lists of learning objects and services are found below activity descriptions. A third tab offers access to lists of learning objects and services independently from the activity tree. This list can be used to access learning objects (like texts to read) and services (like discussion forums) directly.

As long as learning objects and services are provided digitally, they can be accessed directly from this list of objects. In the latter versions of lab005 new browser windows opened for them without navigation features. For adaptability, users can choose to open them in the main window (also used when new windows are blocked by the web browser), but mostly new windows are used to access learning objects and services. As a result, the main window is kept as a central navigation device for controlling and observing the teaching-learning process. In this way the separation of process and content in teaching and learning, which is one central concept of IMS Learning Design, is applied efficiently to the graphical user interface.

Markers, Browsing and Navigation

As a graphical user interface for self directed learning, lab005 offered the possibility for users to browse the entire unit of learning. Learners are not taken in rigorous steps from one learning activity to another. On the contrary, they are encouraged to examine the complete unit of learning, mainly to revisit previous phases or activities. In order to allow learners to browse the whole unit of learning and return easily to the current step in the teaching-learning process, three independent markers are needed:

- A first marker denotes the current view of the teaching-learning process while browsing. A single play, act or activity is chosen by the user and displayed, independently from the learning activity currently performed by the learner. Learners can use any view of the teaching-learning process for exploring the unit of learning. A bold font-weight was used to indicate which step is viewed at one moment of interaction.
- Secondly, the learning activity currently performed is marked as in use by a learner. A bookmark such as that used while reading a book was considered, but a symbol for a floppy disk is instead used to indicate the activity currently performed by a learner. Hence, using the symbol for a floppy disk, a learner can save and recall his or her current activity.
- A third marker is used to give information about the position of the whole group of learners, i.e. the class. A user may use this marker to synchronise his or her view to the step in process where the class as a group (or the majority of the learners) has arrived. This position can be set by a teaching person. A whiteboard is used to indicate this specific point in the representation of the teaching-learning process.

Other solutions on marking progress in teaching and learning addressed the differentiation of past and future phases in the teaching-learning process. Past chapters and phases are dimmed, i.e. grey text is used for their titles. Within the list of all learning objects or services for a chapter, only those assigned to a single current activity are displayed in black, while others were dimmed, too. Nevertheless, all resources are still accessible for browsing the whole course. Given this, a learner can access past and future resources for learning quickly without losing focus on the current learning activity.

Those concepts in the graphical user interface provide features to explore the unit of learning in a self-directed way. In our qualitative studies, this possibility of explorative access proved to be a key to acceptance and ease of use.

Outcomes

Considering the above described concepts of a graphical user interface for units of learning conformant to the specification, some conclusions can be drawn on the employment of IMS Learning Design. They mainly concern issues that arise from practical use in mixed mode learning scenarios, hence in classroom teaching.

Classification of Learning Objects

In IMS Learning Design, a classification of elements in the learning environment is suggested. This classification can be done by an attribute `type` for learning objects (`<imsld:learning-object>`). This attribute is not mandatory, nor is an enumeration given. The specification (Koper et al., 2003b) suggests adopting a classification given in the IEEE LOM standard for meta-data (see Learning Technology Standards Committee of the IEEE, 2002). Services are classified as communication service (synchronous, such as a chat, or asynchronous like a newsgroup), as e-mail communication or as an index search.

In developing lab005, we assumed that this classification could support learners while learning. If elements in the learning environment, learning objects and services likewise, are differentiated by symbols, this differentiation should foster the interaction between learner and teaching staff as well as between learner and system. The categories of elements in the learning environment were oriented on IEEE LOM as well as on contextual requirements for the specific units of learning operated with lab005: *resource, lecture, assignment, exercise, exam, tool, simulation, problem statement, case study, asynchronous conference, synchronous conference,* and *announcement* were used as resources for learning.

But as a result of the qualitative studies, we observed that a classification of elements in the learning environment and a corresponding coding in symbols or text does not foster learners' comprehension of the teaching-learning process. Noting the function of a resource or service for learning (e.g. *lecture* versus *text*, *tool* versus *simulation* and *assignment* versus *exam*) increases the complexity of the graphical user interface rather than supports a learner.

Learners in interaction with an information system for learning obviously anticipate using digital media or communication devices for learning. In classroom scenarios they use non-digital media and real objects as well. The function of these resources for learning is not a major concern for a learner. A learner expects direct access, especially if he or she is well informed about what to do with a resource by an activity description. Following this idea, a learning activity (or a supporting activity) serves as a wrapper element for learning objects and services in a teaching-learning process. Hence, a description of the function of resources has to be contained in the activity description (implicit or explicit). Further noting in the form of an attribute type is redundant and confusing for a learner.

IMS Learning Design in Touch with Reality

IMS Learning Design addresses support for mixed mode (blended learning) as well as for pure online learning (Koper et al., 2003b). Mixed mode learning scenarios imply real life situations in classroom or similar settings, hence direct communication between learners and teaching staff as well as interaction with physical objects like textbooks and tools. For example, in a university course on educational media, a group of learners might be working on a case study where the learners are supposed to outline a concept for a training course introducing a new product. Hence, information brochures about the exemplary company and the product in question, maybe the product itself, are provided as real learning objects. The learners may use sketch pads and a flip chart for their direct communication. While supporting the design process, a teaching person may use a blackboard to note feedback for all groups on issues of group dynamics, creativity and instructional design. Further examples of real life learning scenarios where physical objects are used can be found easily, e.g. in technical courses in higher education or vocational training, where learners regularly use laboratory equipment.

A concept of a 'learning environment' intended to support classroom teaching has to provide facilities to describe physical objects and direct communication. In our practical use of IMS Learning Design in mixed mode higher education, we noticed some difficulties in relation to real life situations. At first, there is a general challenge in referencing from the graphical user interface to real life objects used for learning or to face-to-face situations for communication in class. Users of an information system for learning tend to expect everything to be accessible through the information system itself. Especially with desktop computers, which imply a certain physical setting in the relation of human user and machine, attention is drawn completely to keyboard, mouse and screen. Thus people experience difficulties in interacting simultaneously with the PC and with other persons or objects in real life. With increased usage of mobile devices such as notebooks and PDAs, such problems may decrease. Future application of IMS Learning Design in scenarios of mobile learning will show relevant challenges and solutions.

Nevertheless, IMS Learning Design has to be enhanced further to describe physical objects and direct communication. Of course it is possible to integrate physical objects in a unit of learning as learning objects through a simple description. Also, face-to-face communication settings can be integrated as a type of synchronous conference. However, an attribute is still missing to mark a learning object or a service as not given digitally in the unit of learning and thus existing in real life. This attribute would help to prepare units of learning for runtime through a list of real life objects, which teaching staff has to supply for classroom teaching. If given to the learner through the graphical user interface, this attribute would help to avoid disorientation.

Another cause of disorientation is the combination of learning objects provided in the unit of learning on the one hand and resources linked from outside the unit of learning, i.e. available on the web, on the other. Learners may possibly lose their orientation, particularly if web pages or web-based information systems outside the information system used for learning can be accessed comfortably as learning objects. Hence, elements in the learning environment that lead to external resources should be marked clearly. In conclusion, we suggest three types of availability (`availability-type`) for elements in the learning environment:

- `included` for elements that are digitally integrated in the content package for a unit of learning; thus assets for the unit of learning that are approved and revised resources for learning,
- `real` for elements that are non-digital resources that have to be supplied for classroom teaching or self-study and are used along side the information system that runs a unit of learning, and
- `linked` for elements that are digitally available through the web but not an integrated part of the unit of learning; thus not approved and revised by teaching staff.

For pragmatic reasons, in practical use we consider the attribute `availability-type` far more important than the attribute `type` for a learning object. A compulsory integration would enhance the implementation of IMS Learning Design in mixed mode scenarios.

Complementary Activities in Classroom Situations

As discussed above, mixed mode learning scenarios, which are addressed by IMS Learning Design, imply real life situations in classrooms or similar settings. Regardless of whether we call them tutorials, seminars, lessons or training, in these situations learning activities and supporting activities take place in close relationship: same time, same place. Activities of learners and teaching staff imply immediate interaction, where learning activities and supporting activities are connected in a complementary manner. In common learning scenarios like seminars, lessons or training situations, examples for complementary activities suggest themselves: While a lecturer explicates an issue concerning a subject to learn, learners listen and may take notes. While learners discuss an issue, one person leads the discussion. While learners perform a task for learning on their own or in a group of learners, a tutor will assist and be prepared for questions.

In these teaching-learning situations, specific learning activities imply specific supporting activities and vice versa. In addition to classroom teaching, this also applies to certain scenarios in online learning, where a high degree of synchronicity is given, such as in chats or virtual classrooms. Learning and supporting activities that are closely interrelated we call complementary activities.

In contrast, in online learning, interaction between learners and teaching staff (and, to some extent, interaction between learners and information systems alike) can be described more as a sequence of moves in a game rather than through complementary activities. A typical assignment in higher education can serve as a simple example for this kind of move-by-move approach: In a first move, a tutor addresses an assignment to the learners. In a second move, a learner works on the assignment and submits it back to the tutor as a third move. In a fourth move, the tutor assesses the assignment and provides feedback as a final, fifth move. IMS Learning Design follows the notion of moves in a game in connecting learning and supporting activities to roles in role-parts subordinate to acts. For asynchronous interaction between roles, clear separation of phases in the unit of learning by acts works well. Here, the origin of IMS Learning Design becomes evident: The preceding specification EML (Educational Modelling Language) was developed for online learning scenarios at the Open University of the Netherlands.

But in learning situations in classrooms or similar settings, the description of interactions between learners and teaching staff in role-parts subordinate to acts becomes very complex and redundant. For complementary activities, one activity implies the activity of a counterpart, so only a leading activity has to be described. In order to integrate the notion of complementary activities in real life learning scenarios better, we suggest introducing an element like activity-situation, which can be assigned to learners and teaching staff at the same time and give a comprehensive description of the direct interaction between both roles.

Conclusion

This article provides an account of the web-based learning environment lab005 implementing basic concepts of IMS Learning Design. As neither runtime environments nor authoring systems were existent when IMS Learning Design was published as a final specification in February 2003, lab005 was built as a prototypical runtime environment for IMS Learning Design extending Moodle, an open source course management system. Several university courses (and an exemplary unit of learning for use in usability tests) have been developed and have been in operation on a regular basis since then.

These courses provided a use case for the empirical review of IMS Learning Design. In terms of usability, one outcome of this evaluation concerns the interaction of users in learning situations with a learning environment for IMS Learning Design. A user-centred evaluation analysed key concepts for a graphical user interface, which represents essential concepts of IMS Learning Design in a meaningful manner to both learners and teaching staff. Key concepts for a graphical user interface addressed useful representation of a hierarchical and sequential organisation of learning (and supporting) activities, representation of single activities, representation of resources for learning and markers in the teaching-learning process. For the representation of the teaching-learning process in an activity tree, a reduction of complexity was gained through separation of three levels of details in aggregation, i.e. a view for the whole course down to phases (i.e. 'acts' in LD terms), a view for a unit of learning down to single activities and a view for a single activity with a list of resources needed to perform this activity. For representing a single learning (or supporting) activity, a cue-card with a simple list of resources, i.e. learning objects and services, proved to be a viable concept. Hence, the notion of an environment tree was abandoned in favour of reducing complexity. Markers for the current view, for the current activity performed by a single user and for the current position of the whole course support learners in self-directed and explorative use of a unit of learning.

As a second outcome of the empirical review, some further conclusions can be drawn on the use of IMS Learning Design in mixed mode learning scenarios (use for blended learning), which mainly concern issues that arise from classroom teaching and similar learning situations, e.g. vocational training. At first, a classification of learning objects by type (e.g. *lecture* versus *text*, *tool* versus *simulation* and *assignment* versus *exam*) is not a major concern for learners and unnecessarily increases the complexity. A differentiation of availability (i.e. included, real or linked) appears to be more helpful. Especially in classroom situations or vocational training, where real objects and direct communication are part of teaching and learning, an indication for a reference to an object or a communication situation outside the web-based learning environment in the real world is essential. Since direct communication in classroom teaching implies complementary activities, where activities of learners are a counterpart to activities of teaching staff and vice versa, a strict division of activities for learners from the activities of teaching staff (in role-parts) leads to a complex and redundant description of the teaching-learning process. A possibility to note these steps in a learning scenario as an 'activity situation' would foster scope and completeness of IMS Learning Design.

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Knowledge base for automatic generation of online IMS LD compliant course structures

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ABSTRACT

Our article presents a pedagogical scenarios-based web application that allows the automatic generation and development of pedagogical websites. These pedagogical scenarios are represented in the IMS Learning Design standard. Our application is a web portal helping teachers to dynamically generate web course structures, to edit pedagogical content and to administer their courses. In this paper we are describing the methodological framework and the theoretical approaches used in our research project. We will also make a brief presentation of how the structures are automatically generated. Our application uses a knowledge-based system developed in the JESS environment (Java Expert System Shell). The knowledge is represented in XML files, then translated in JESS rules. Finally we are presenting an example of an educational website structure model developed using our tool and we are presenting an IMS LD graphical editor for modifying the course structures as well.

Keywords

Pedagogical scenario, Knowledge based system, IMS LD graphic representation, Instructional theory, Dynamic generation of pedagogical website structures, HCI (Human-Machine Interface) for websites.

Introduction

Today, the Internet and web development has transformed teaching and training practices. Courses circulate through software platforms in many formats and varied structures.

Considering the diversity of digital material and taking into account that users can access these elements, distribute them, exchange them, update them, the designers of electronic teaching objects have underlined the importance of standards. These are presented in the form of a "common language", which is currently used for indicating, organizing and describing the digital educational resources.

Our analysis regarding various norms and standards (IEEE, 2001; Friesen, 2002; ADL, 2001; IMS, 2003) enabled us to choose the IMS LD standard for representing the pedagogical content in models of educational websites. In the realization of these teaching models, we are interested in taking into account several concepts like: theories and models of teaching and training, curricular areas, roles of actors (learners, group leaders, professors, tutors, etc.) and interactions between these various actors in the training environment. The use of this language facilitates the implementation of the dynamic evolution of a training course. Consequently, all elements that have been described led us to apply the IMS LD standard in the creation of educational websites.

Learning Design Existing Tools: some examples

Griffiths et al. (2005) classifies the authoring tools dedicated to the design of a unit of learning in two categories: "low level" tools (use a presentation of terms and structures is close to the IMS LD specification) and "high level" tools (using a presentation of terms and structures distant from the IMS LD specification and also utilising a "hidden mapping" between the interactions of the users and the IMS LD document which must be published). The target for the first category is users (pedagogical content creator) with a deep knowledge of IMS LD specification. For the second category ("high level") of tools, the target users are those who are not familiar with the IMS LD specification. Therefore, the IMS LD structure and terminology are considered inappropriate for them. In order to be easy to use, these "high level" tools integrate vocabularies and representations well recognized by users. For example, teachers, as well as other actors who take part in the creation of the online courses, are familiar with terms like lesson, module of teaching, exercises etc. Consequently, they must specify and visualize the development of their courses by using these terms, which do not necessarily have a direct equivalent in LD.

Another direction that we can take into account in the classification of the authoring tools refers to the generic and specific dimensions of these tools (Griffiths et al., 2005). Thus, the tools known as "generic" give users access to the whole specification of LD. This category of tools is used by specialists in pedagogy, but also by technical specialists designing the units of learning.

Thereafter we give some examples of tools based on IMS LD. These tools are divided into three main categories: learning design editors, runtime tools and learning design players.

Learning Design Editors

RELOAD LD Editor

The RELOAD project (Reusable e-Learning Object Authoring and Delivery) is a project of JISC whose objective is the development of tools in order to facilitate the use of interoperability specifications for pedagogical technology such as those created by ADL and IMS (Reload, 2005). Reload LD Editor is an authoring tool developed at the University of Bolton by Phillip Beauvoir and Paul Sharples. It proposes a graphical environment used for editing and conceiving packages in conformity with the IMS LD specification. The second version supports levels A, B and C of IMS LD and is currently available on the project website (Reload, 2005).

The Reload LD Editor allows the import and the creation of IMS LD packages. For each unit of learning, we can find the buttons corresponding to the principal IMS LD concepts: roles, activities, properties, environments, as well as plays structured in acts and role-parts. The process of conceiving a unit of learning consists of filling in all the fields, according to the IMS LD specification.

CopperAuthor

CopperAuthor is an IMS LD editor developed by the OUNL (CopperAuthor, 2005). It provides a graphical interface that gives the user the possibility of developing and validating units of learning, visualizing the resulting XML code and unifying incomplete units of learning. It is not yet possible to import units of learning. CopperAuthor also provides a graphical interface to assign roles with runs in Coppercore and a previsualisation with Coppercore for executing the created course.

Learning Design Engine and Players

CopperCore

CopperCore (CopperCore, 2005) is an IMS Learning Design engine developed by the OUNL in the context of the Alfanet project which supports all three levels of this standard (A, B and C). It handles the business logic of Learning Design by providing support for dynamically checking and personalizing the activity workflow in an IMS LD content organization. The implementation of IMS LD business logic as a separate software unit with an API facilitates the development of IMS LD players by hiding all the complexities of this standard. Thus, the CopperCore engine can be used when developing players that interpret IMS LD.

Reload Learning Design Player

An example of a tool that uses the CopperCore engine is the Reload Learning Design Player (Reload, 2005), developed at the university of Bolton by Paul Sharples and Phillip Beauvoir. Using this tool, it is possible to manage several units of learning at the same time. The features of this LD player are: wraps the Coppercore (version 2.2.2) runtime engine within an easy to use management interface; automatically launches and deploys Coppercore under a JBoss server; interface allows for easy import/removal of Learning Designs in the Coppercore engine without the use of command line tools; automatically reads a Learning Design and populates Coppercore with a default run and active user for every role found within the manifest.; easy launch - double click a role within the management interface and it launches in the Native Browser.

In the section, describing the positioning of netUniversité in the context of existing LD tools, we position our tool in comparison to the other tools presented here.

Applications of IMS LD: pedagogical website models

We have designed an online guide called CEPIAH in order to help teachers to implement pedagogical websites and to produce on-line courses. This system is composed of three modules: Help in the Design and Help with the Evaluation and Assistance with the development of online course structures. After having integrated the first two modules into the CEPIAH guide (Trigano & Giacomini, 2004; Giacomini & Trigano, 2003), in the third module we were interested in assisting the design and development of educational website structures. We developed a Web portal, named netUniversité, of which the general architecture is represented in Figure 1. Using this application the teacher can automatically generate educational website structures, adding the pedagogical content to these structures, then visualize, manage and participate in his courses. The students can view and participate in courses using the navigator integrated in netUniversité. Our web portal netUniversité, also integrates a QTI editor for interactive exercises (see Giacomini et al, 2005).

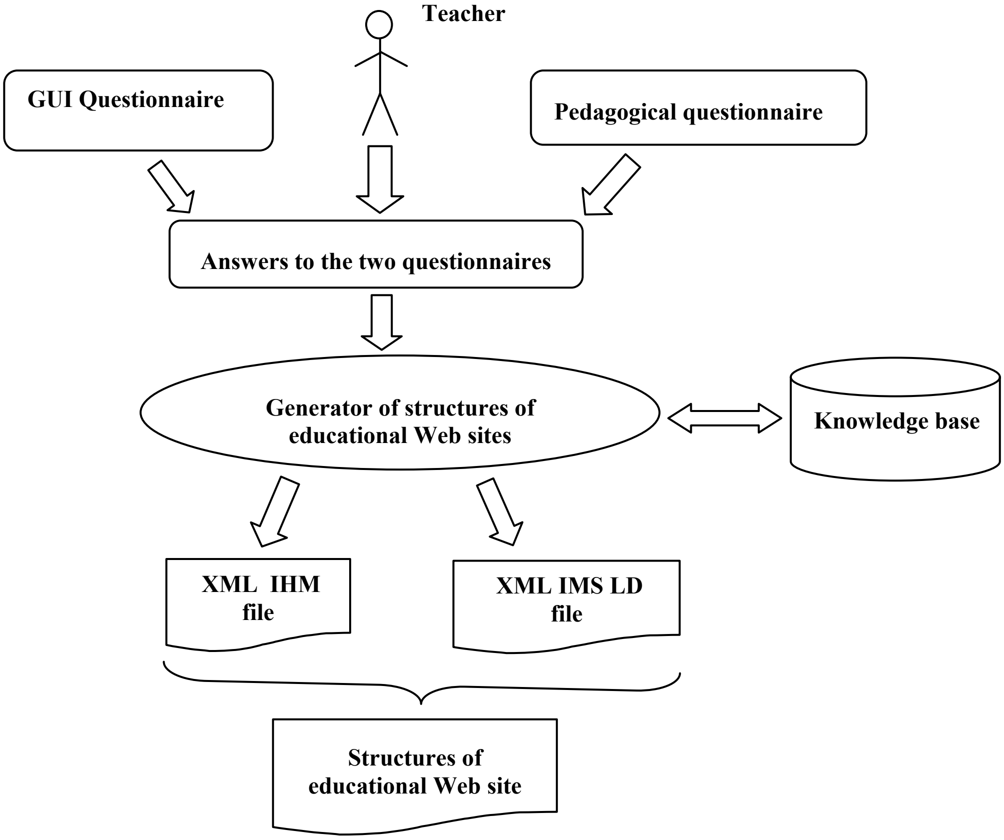

Figure 1. The general framework of automatic generation of educational websites

These structures are generated starting from answers given by the user (the teacher) by responding to two interactive questionnaires: a pedagogical questionnaire and a GUI related questionnaire (cf. figure 1).

A more detailed description of the principle of generating educational websites structures will be the subject of the following section.

Proposing unit of learning models represented in IMS LD by using an inductive and deductive approach

In this section we present our approach for the creation of the basic pedagogical models used in the process of automatic generation of the educational website structures. Thus, we applied two approaches: inductive, which consists of analyzing a base of 170 educational websites accessible through the Intranet at our Technology University of Compiègne, and another deductive approach which consists of an analysis of a bibliographical study on various theoretical approaches of learning and teaching. The analysis of the educational websites was made with an aim of achieving two goals: the prime objective was to find the types of pedagogical units (scenarios) most often used; the second objective was to determine the components for the graphical aspects of the interface of pedagogical websites (colors, the shapes of the menus and buttons, etc.). We present below the results of the analysis of the educational websites from a pedagogical point of view and then we present some theoretical approaches which we studied with the aim of enriching typology of the pedagogical units (scenarios) obtained during the inductive analysis. The results of the inductive analysis on the graphical aspects will be presented in the following section.

Inductive approach

As we mentioned above, this analysis also allowed us to collect information concerning the pedagogical elements that comprise an educational website. In order to structure the great amount of information concerning the pedagogical concepts, we proposed some criteria like the existence of: theoretical parts in a formation module, exercises of various types (QCM, problems to be solved, text to be completed, etc), projects, types of evaluations, auto-evaluation, etc.

Generalizing these criteria we determined three main types of pedagogical units to be included in a course: presentation of theoretical concepts, exercises (course application) and projects (practical work). From a pedagogical point of view, these pedagogical units were limited to a simple presentation of content, often not well structured. Moreover, the reduced numbers of proposed projects were not conceived to encourage group work, debates and discussions on forums.

Deductive approach: a review of instructional design theory and models

The last century marked the appearance and the development of theories, models and methods of teaching and training, starting with Piaget's work (Gallagher & Reid, 1981) concerning the constructivist approach, the socio-cultural approach of Vygotski (1978), and ending with Gagné's and Medsker's work (Gagné & Medsker, 1996) on the conditions of training and Merrill's work (Merrill, 2002) on the identification of the fundamental principles of teaching and training. We can also mention Reigeluth's work (Reigeluth, 1999), which proposes several models and methods of teaching, integrating various teaching scenarios as well as the work of Paquette (2002) on teaching engineering for the systems of e-learning. In the first phase of work, we studied some of these models applied to our proposal for teaching scenarios. In the following paragraphs we present the fundamental principles of teaching and training suggested by Merrill (Merrill, 2002), and give some examples of teaching and training models using these principles, that we take into account in the design of the pedagogical models of the websites. Several methods of teaching suggest that the majority of the training environments are problem solving based and involve the students in four phases of training that Merrill (Merrill, 2002) distinguishes: (1) activation of former knowledge, (2) demonstration of competences, (3) applications of competences and (4) integration of these competences in the activities of the real world.

An example which includes all the learning stages that Merrill talks about, is the approach based on the collaborative problem solving proposed by Nelson (Nelson, 1999). In this case, much more importance is accorded to the application stage rather than to the demonstration stage. In order to help the designers of pedagogical scenarios such as 'project based learning' or 'collaborative problem solving', Nelson proposes a guideline including recommendations structured on various stages of activity, as follows: define the goals and the plan of the project, set up groups of learners, define the issues, define and assign the respective roles, involve the learners in a repeating process of problem solving, end the project, reflect upon it, synthesize and assess the results obtained.

The constructivist approach of Jonassen (1999) is also centered on problem solving of projects by including all the principles of training mentioned by Merrill (2002). Jonassen says that the training is favored when the learners discover the contents of the field through problem solving. Moreover, he recommends a progression in the resolution of problems: "start the learners with the task they know how to perform and gradually add task difficulty until they are unable to perform alone" (Jonassen, 1999).

Schank (1999) proposes a model of "learning-by-doing", GBS (goal-based scenario) centered on the resolution of the problems by using reasoning starting from cases (box based reasoning). This model insists on the phases of application, activation and demonstration; the phase of integration is accentuated. In this model, learners must achieve the goals of training by applying their competencies and using related content knowledge (presented in the form of cases), which can help them in the achievement of their objectives.

Another example is the approach called "Elaboration Theory" proposed by Reigeluth (1999). With the same point of view as Jonassen, Reigeluth recommends a «simple towards complex» organization of the teaching content, by stressing that: "... the simple-to-complex sequence is prescribed by the development theory because it is hypothesized to result in: the cognitive formation of more stable structures, hence causing better long-term retention transfer; the creation of meaningful contexts within which all instructional content is acquired [...] ". In addition, Reigeluth considers that at the beginning of a course it is desirable to pre-evaluate the participating students.

In general, we can observe that all these approaches take into account the fundamental principles of learning stated by Merrill. Another common point aims at the aspect centered on the problem solving or project-based work, which can be carried out individually or by groups.

The study of various theoretical approaches of teaching and training was useful to us as a theoretical support in modeling the teaching models of pedagogical scenarios. The website structures generated by the course generation module are based on teaching models of scenarios that integrate, according to the case, the characteristics of these theories. In the section, describing an Example of "Branched Exercises" unit of learning, we present an example of a pedagogical scenario based on certain characteristics of the "Elaboration Theory" approach.

Proposing pedagogical unit models combining the two approaches

As we mentioned above, this analysis also allowed us to collect information concerning the pedagogical elements that comprise an educational website. Starting from these three main types of units obtained by inductive analysis we created 17 models of pedagogical units associated with pedagogical scenarios (plays), by taking into account the characteristics resulting from the theoretical approaches presented above. By using an adaptation of criteria suggested by Reeves & Reeves (1997) for the characterization of a training course, table 1 presents the types of pedagogical units that we integrated in the knowledge-base used by the module of generation of educational website structures (called *Generator*) implemented in the netUniversité portal. We mention here that these types of pedagogical units are basic models (building blocks) but they can, according to the answers to the teaching questionnaire, also be used like final models (resulting course structures).

These different types of pedagogical units are modeled in the UML activity diagram, then we formalize them in XML-IMS-LD (IMS, 2003).

Table 1. Analysis of a unit of learning based on the model proposed by Reeves (Reeves and Reeves, 1997)

Model No	**Reeves' Criteria / UOL Type**	**Orientation of learning activity (Academic and/or Applicative)**	**Group working**	**Teacher's role**	**Communication tools**	**Type of evaluation**	**Theoretical approach**
1	**Problem solving /exercises (Branched itinerary)**	Applicative	no	Rather Transmissive	X	Formative	Rather Academic
2, 3	**Learning theoretical concepts with exercises**	Academic	no	Rather Transmissive	Email	Formative	Rather Academic or inspired by Elaboration Theory
4	**Learning theoretical concepts, exercises, problem solving**	More Academic than Applicative	no	Rather Transmissive	Email	Summative and Formative	Rather Academic (behaviourist)

5, 6	**Problem solving (Sequential and flexible itinerary)**	Applicative	no	Rather Transmissive	X	Formative	Rather Academic (behaviourist)
7, 8	**Problem solving (Sequential itinerary)**	Applicative	yes	Moderator	Email Forum	Summative and Formative	Rather constructivist
9	**Learning theoretical concepts, problem solving**	Academic Applicative	yes	Transmissive Moderator	Email Forum	Formative	Instructivist and constructivist tendencies
10, 11	**Learning theoretical concepts**	Academic, students participation	yes	Transmissive Moderator	Email Forum	Formative	Instructivist and Constructivist tendencies
12	**Learning by project**	Applicative	no	Guide	Email Forum	Summative Formative	Constructivist
13	**Collaborative learning by project**	Applicative	yes	Guide	Email Forum	Summative Formative	Constructivist (social aspects)
14, 15	**Learning by project based on « active pedagogy »**	Applicative	yes	Observer	Email Forum	Summative Formative	Constructivist Active Pedagogy
16	**Modelation and problem solving**	Applicative (pairs)	no	Guide	Email Forum	Formative	Constructivist Cognitive apprenticeship
17	**Learning by project based on analysis of questions/problems**	Applicative	yes	Moderator	Email Forum	Summative Formative	Constructivist Project of analysing questions /problems

Interactive questionnaires for the dynamic generation of educational Website structures

In order to generate the website structures, our system uses as input the answers of the two interactive questionnaires represented in XML files: a pedagogical questionnaire and a questionnaire for the aspects of the graphical interface. Each generated website structure is represented by two XML files, one for the graphical interface models and another for storing the pedagogical content organized in IMS LD format.

The design step for the pedagogical questionnaire

The module for dynamic generation of online course structures (see figure 4), integrates several teaching scenarios represented in various structures of websites. The goal is to help non-competent teachers create their own course in the form of a website. In order to reach this goal, we have chosen an automatic course generation approach, from the dynamic questionnaire. We think this approach will induce or help teachers to think about their pedagogical practice by making them evolve towards different methods, which may be more suitable for current needs in the training domain, by using web technologies.

Our pedagogical questionnaire makes it possible for the user to dynamically choose the elements that will be integrated in his and her educational website. This questionnaire is structured on three levels of granularity: a question itself, its reformulation as well as an in-depth explanation related to this question (see figure 2). In the in-depth explanation, we present a short synthesis on the theoretical concepts of teaching and training, connected to this question, while also explaining the consequences for the website structure.

The design step for the dynamic questionnaire for website interfaces

The analysis of the great number of educational websites evoked in the previous section also enabled us to determine various types of possible interface models. Several criteria are taken into account: navigation starting from the menus, the shapes of the buttons of navigation within the various pages of the website, the colors of the menus and the buttons, etc.

In our approach we consider that a website structure is composed of two elements (figure 3): *structure* and *appearance*. The *structure* is made up of two types of navigation (general and secondary) plus a central page. Some of these elements are represented in a XML diagram (figure 3), obtained using the XMLSpy software.

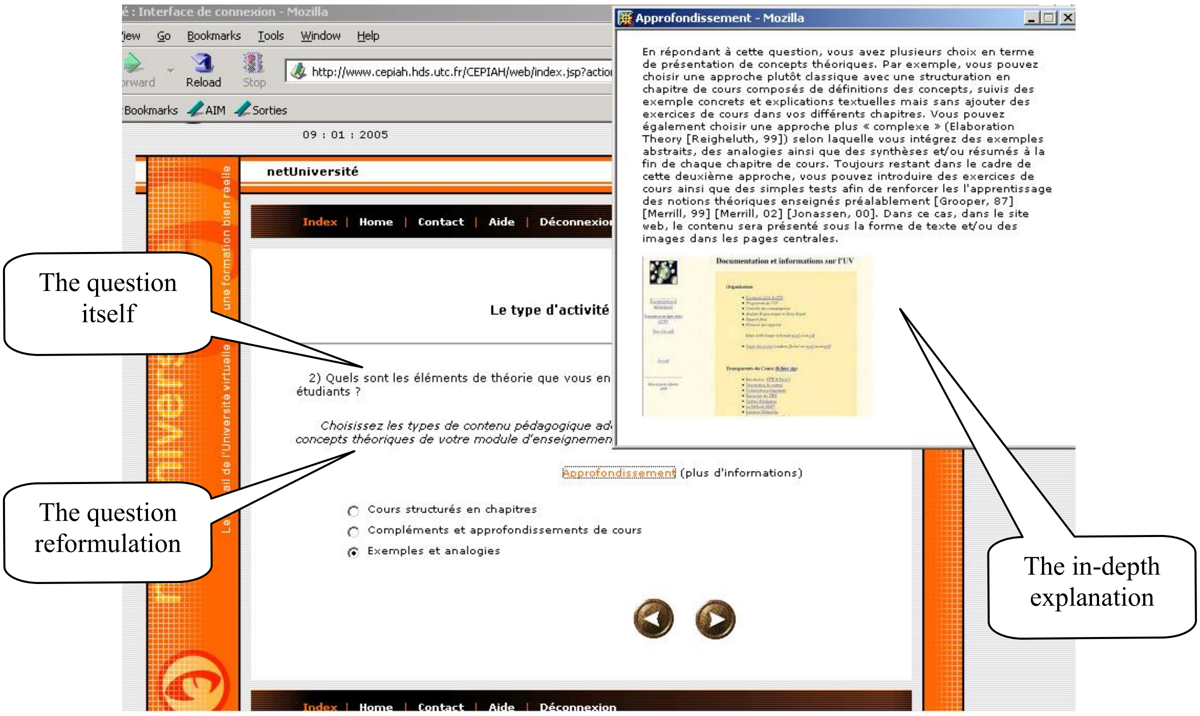

Figure 2. An example of the pedagogical questionnaire web interface

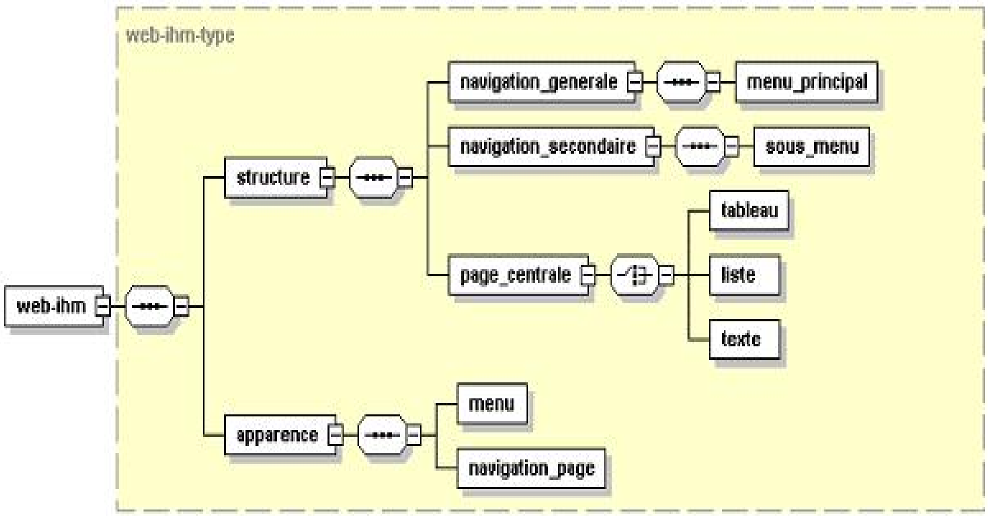

Figure 3. XML diagram for the interface of the pedagogical websites

The principal navigation relates to the main menus, which are integrated in the websites starting from the banner page. Thus, we can distinguish the menu allowing navigation on top of the page, the menu allowing navigation in the left part of the page as well as the central menu. We can also modify the type of initial navigation by adding different menus compared to that which is on the banner page. The navigation resulting from this modification is called secondary navigation. *The presentation of the central page* relates to the various forms of presentation that can be used, for example: lists, tables, etc. *Appearance* represents what is related to the esthetics of the interface of an educational website. Thus, we can take into account: colors, the shapes of buttons in the menus and/or for navigation within the pages and images representing a given curricular area.

By using this typology, we designed a dynamic questionnaire that allows the choice of the graphical aspects of the interface for the website. Figure 4 shows an example question implemented in this questionnaire.

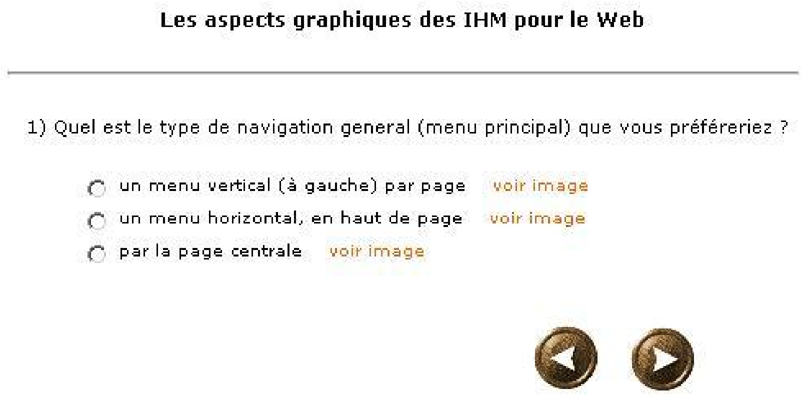

Figure 4. Example of question integrated in the dynamic websites interfaces questionnaire

Two types of graphical interface are considered for the generated courses: a simple, *standard interface* and *predefined models of interface*. While answering a certain question, the teacher has the possibility to choose the desired type of interface before the course is generated. The functions of the selected type of interface, the IHM attributes are used either to define the characteristics of the standard interface (colour, position of menus etc), or to select the predefined model of interface, appropriate to the answers of the teacher.

Automatic generation of educational websites structures

Modeling of the knowledge base

The problem of the complexity of the conditions used for the automatic generation lead us to a knowledge-based system. The number of entries (represented by the possibilities of response to the questionnaires) and the great number of choices concerning the teaching models required us to develop a rules-based system. In order to implement these rules we chose an environment for developing the expert systems in Java, named JESS (Java Expert System Shell). JESS is a library written in Java, for Java, which can be used for the development of the Web applications containing applets or JSP pages (Java Server Pages).

The treatment of the answers to the questionnaire is complex because it implies knowledge about several theories and models of training, such as behaviorism, constructivism, socio-constructivism, etc. To obtain independence between the executive part (generator) and the data part (teaching knowledge) we separated these two parts by conceiving an XML schema for representing this knowledge. Thus, the knowledge base can be developed independently by publishing a simple XML file without affecting the generator. Knowledge is stored in XML, in a format similar to a JESS rule. It will be transformed into this language and will be added in the inference engine before being treated by the generator.

An automatic tool for generation of pedagogical websites

In order to generate the pedagogical website structures, we use a list of primary pedagogical models (i.e., basic models) also named *building blocks*. These building blocks are used to build the final models (structure of the generated course). The inference rules in the knowledge base specify the way in which these elementary bricks are associated (figure 5). The latter are IMS LD components which can be created by default at the time of generation or conceived beforehand and recorded in XML files that apply this standard.

The primary pedagogical models are specified in the XML file that represents the knowledge base. The elements that characterize these models are a single identifier (id) of the model, a title, and a type (teaching unit, scenario, activity of training, etc.). If the primary education model was recorded, this information is also specified. These models can be created starting from several levels of depth in IMS LD. For example, we can consider either an entire unit of learning or only some blocks used to build a unit of learning: plays, learning-activities and/or support activities, activity-structures, environments, etc. Thereafter we describe the operation of an automatic tool for generation that we have developed. Thus, the answers from the two questionnaires are translated into the JESS format and are loaded in the inference engine (figure 5). Once the inference process is complete, the rules will create two types of facts: the facts that represent IHM attributes (description of the graphical interface of the pedagogical website) and the facts that establish links between the primary pedagogical models. These facts become the entries for the *CourseBuilder* of the models.

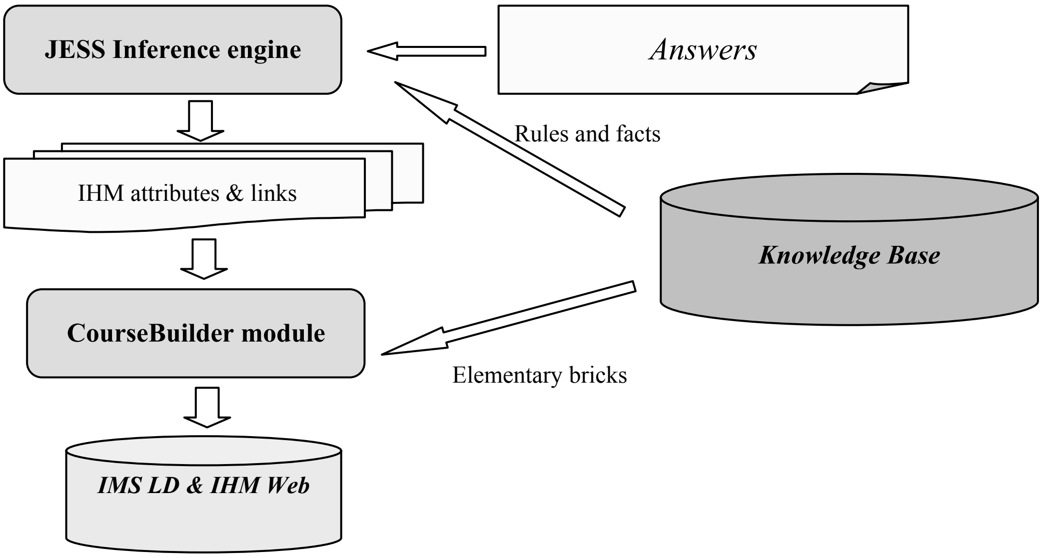

Figure 5. Automatic generation of the educational websites

As we mentioned above, the generation of course structures is realized starting from answers to the two interactive questionnaires. These answers constitute the *initial facts,* which are translated into JESS format by the *JESS Translator* module and are loaded into the inference engine (figure 6). Two types of facts are distinguished as a result of the inference process: facts describing the *GUI attributes* of the resulting website structure and facts establishing the *links* between the basic pedagogical models. The significance of the bricks was presented above. These two types of facts represent the inputs for the two blocks: the *Interface Builder* and the respective *CourseBuilder*. Thus for each generated website structure, these modules will create two files that describe the resulting course: *web-ihm.xml* (for the description of the GUI elements) and *imsmanifest.xml* (for the description of the pedagogical content).

We describe below each software module used in the automatic generation of online courses.

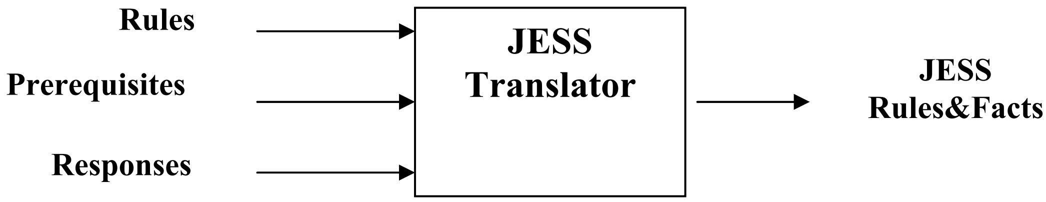

Figure 6. JESS Translator

JESS Translator

The *JESS Translator* module transforms the rules and the initial facts represented in XML and Java objects (in the case of responses to questions) into JESS format. This module is a Java class that has static methods to translate the knowledge base represented in XML (initial facts and rules) into JESS rules and facts. We have also created a function that transforms the Java object containing the responses to the questionnaires (*QResponses*) in JESS facts (figure 5 and 6).

For example, an initial fact (prerequisite) represented in XML (figure 7a) is transformed by the *JESS Translator* block into a JESS fact (figure 7b). In our case, the fact represented in figure 7 establishes a link between a pair *GUI attribute - value* (*menu_type - vertical*) and a pair *question - answer* (*1-1*).

```
<fact name="ihm-qattribute">
  <slot name="attr-name" value="menup_type"/>
  <slot name="attr-value" value="vertical"/>
  <slot name="qno" value="1"/>
  <slot name="qresponse" value="1"/>
</fact>
```

```
(ihm-qattribute
    (attr-name „menup_type”)
    (attr-value „vertical”)
    (qno „1”)
    (qresponse „1”))
```

Figure 7. Transformation XML - JESS. a) XML fact. b) JESS fact

Inference engine

After the transformation of the knowledge base into JESS, the rules and facts are then loaded into the JESS inference engine. It will execute the rules in a chain, based on the prerequisites (initial facts), the resulting partial conclusions, and then the final conclusions. These final conclusions are the facts that establish the links between the basic pedagogical models composing the course structure and between the GUI attributes of the resulted website.

The Course Builder

Starting from the links established between the basic pedagogical models, the *CourseBuilder* loads these models (if they are saved on disk) or it creates them (in conformance with the corresponding specification in XML knowledge base file), and associates them in order to obtain the desired course structure.

The example of figure 8 shows the way in which the links define a resulting model of the course that is generated. Starting from the element "*root*", which defines a generic (empty) unit of learning, the *CourseBuilder* considers each *child* element associated with a *parent* element, and realizes the link between them in terms of Learning Design specification (e.g. a child element *play* is added to the parent element *learning-design*). This process is repeated recursively for each one of the children (considered as parents) and represents in fact the in-depth creation of an IMS LD tree: unit of learning, play, activity structures and learning activities.

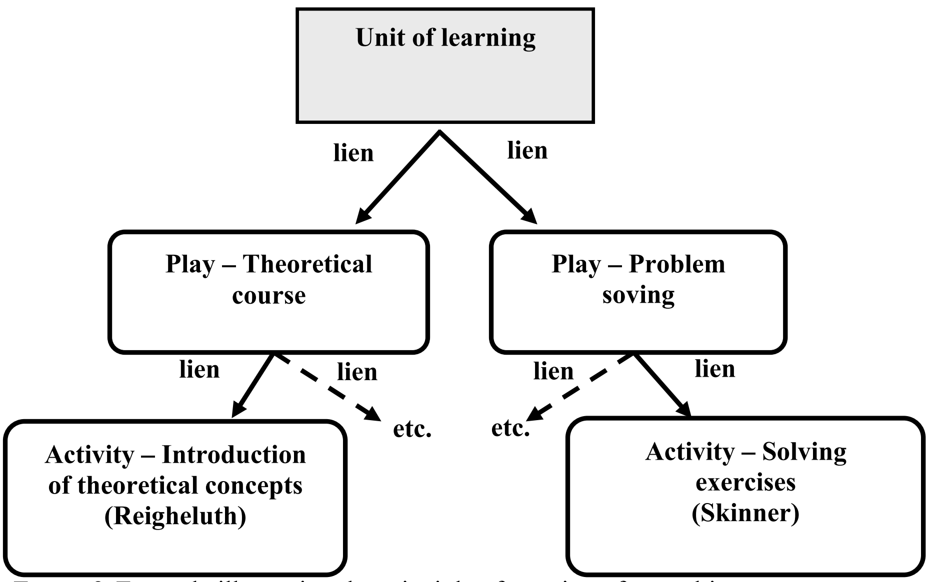

Figure 8. Example illustrating the principle of creation of a resulting course structure

In our case, a fact of type *link* adds an element *child* to an element *parent*. In the structure of this fact we can distinguish:

model-no : the number of the resulting model
id-el1 : ID of the basic model *parent*
id-el2 : ID of the basic model *child*
id-parent : ID of the direct parent (if we want to associate a child to another element inside the *parent* basic model)
order : order number (establishes the position number of the child element).

The generation of the course structures with netUniversité is implemented in all levels of IMS Learning Design: A, B and C. Thus, the predefined models used by the generator can contain elements specific to the advanced levels (B and/or C): properties, conditions (local - within a certain activity - and global) and notifications. On the other hand, to use models on the levels B and/or C in the course structures, it is necessary that these models are predefined. The course builder does not have the capability to create these types of the models during the process of generation.

Forward-chaining rules used for creating course structures

In the process of creation of the educational websites structures, the *Generator* module (figure 5 above) integrated in the netUniversité portal, uses a knowledge base represented in a file *knowledge.xml*. During the process of generation, this knowledge base is loaded in the inference engine JESS. The structure of this file integrates the following main components:

the declaration of basic models – *model-templates*
the definition of facts used by rules – *fact-defs*
the initial facts – *prerequisites* (that includes the responses to questionnaires and represent the initial state of the knowledge base)
the inference forward-chaining rules – *rules*

We present below the way these components are used in order to obtain the final structure of educational websites.

Example of rules used to build the resulting UOL structures

The rules are used to generate the links that define associations between the basic pedagogical models in order to obtain the resulting course structure. Each resulting model is associated with a number for identification. We developed three levels of rules corresponding to the three levels of depth in IMS LD.

```
<fact-def name="root">
  <slot-def name="model-no"/>
  <slot-def name="id-el"/>
</fact-def>
```

Figure 9. Definition of fact root

The rules used to specify the root and the numerical order of a final model constitute the first level of activation. As we can observe in figure 9, the root is specified by a fact named *root* composed of an order number (*model-no*) and the ID of the basic pedagogical model representing the root (usually is a *learning-design* element).

The rules of this type use the responses to the questions to create the fact *root* as well as the facts that specify the pedagogical concepts used in the creation of the course (figure 10). These facts are used by the third level rules in order to select the basic pedagogical models of type *activity-structures*.

Example of a translation in natural language of a first level rule:

If
The plays « Theory » AND « Problems » AND « Project » were selected
AND

The type of « Theory » is a model based on « CDT »
AND
The type of « Project » is a basic model based on individual work
AND
The type « Exercises » is a model based on the approach « programmed teaching » proposed by Skinner

Then
Associate the root of *model n° 1 with the facts CDT, ProjetSimple and Skinner* (these facts indicate the scenarios/plays to be used)

```xml
<rule name="rule-m1">
  <if>
    <pattern name="response">
      <slot name="qnnaire" value="0"/>
      <slot name="qno" value="elemSite"/>
      <slot name="val" value="theoPbProj"/>
    </pattern>
    <pattern name="response">
      <slot name="qnnaire" value="0"/>
      <slot name="qno" value="elemTheor"/>
      <slot name="val" value="explRef"/>
    </pattern>
    <pattern name="response">
      <slot name="qnnaire" value="0"/>
      <slot name="qno" value="typeProj"/>
      <slot name="val" value="projS"/>
    </pattern>
    <pattern name="response">
      <slot name="qnnaire" value="0"/>
      <slot name="qno" value="typeApprent"/>
      <slot name="val" value="appLin"/>
    </pattern>
  </if>
  <then>
    <assert>
      <fact name="root">
        <slot name="model-no" value="1"/>
        <slot name="id-el" value="LD-Generic"/>
      </fact>
      <fact name="cdt">
        <slot value="1"/>
      </fact>
      <fact name="skinner">
        <slot value="1"/>
      </fact>
      <fact name="reighProj">
        <slot value="1"/>
      </fact>
    </assert>
  </then>
</rule>
```

Figure 10. First level rule (creating the root*)*

```xml
<rule name="rule-1">
  <if>
    <pattern name="response">
      <slot name="qnnaire" value="0"/>
      <slot name="qno" value="elemSite"/>
      <slot name="val" value="theorie"/>
    </pattern>
    <pattern name="root">
      <slot name="model-no" value="?mno"/>
      <slot name="id-el" value="?root"/>
    </pattern>
  </if>
  <then>
    <assert>
      <fact name="link">
        <slot name="model-no" value="?mno"/>
        <slot name="id-el1" value="?root"/>
        <slot name="id-el2" value="P-Theorie"/>
        <slot name="order" value="1"/>
      </fact>
    </assert>
  </then>
</rule>
```

Figure 11. Second level rules (association of scenario*)*

A second level of rules is used to associate pedagogical scenarios (plays) to the root, according to the answers to questions referring to the basic pedagogical elements used in the course (theory, exercises, project, etc). For the moment we take into account three types of scenarios that can compose a course: learning theoretical concepts, problem solving and work by project. For each one of these scenarios we conceived a second level rule (figure 11).

Example of translation in natural language of a second level rule:

If
The *Play « Theory » was selected*
Then
*Associate a play « P-Theory» to the root of the model indicated by "**mno**"*

The third level of rules associates an activity-structure to a play. This activity-structure is specified by the simple facts generated on the first level of rules and represents a basic pedagogical model saved on a disk (or created at runtime) (figure 12).

```
<rule name="rule-cdt">
  <if>
    <pattern name="cdt">
      <slot value="?mno"/>
    </pattern>
  </if>
  <then>
    <assert>
      <fact name="link">
        <slot name="model-no" value="?mno"/>
        <slot name="id-el1" value="P-Theorie"/>
        <slot name="id-el2" value="AS-CDT-type1"/>
        <slot name="id-parent" value="RP-Theorie"/>
      </fact>
      <fact name="link">
        <slot name="model-no" value="?mno"/>
        <slot name="id-el1" value="P-Theorie"/>
        <slot name="id-el2" value="student"/>
        <slot name="id-parent" value="RP-Theorie"/>
      </fact>
    </assert>
  </then>
</rule>
```

Figure 12. Third level rule (association of an activity-structure)

Example of translation in natural language of a third level rule:

If
The fact CDT is defined
Then
Add into the role-part « RP-Theorie » of play « P-Theorie » the activity structure « AS-CDT »
AND
Add into the role-part « RP-Theorie » of play « P-Theorie » the role « Student »

The structure of these inference rules enabled us to easily implement the mechanism of association between various basic pedagogical models, as well as their integration with models of graphical interface in order to obtain the resulting pedagogical website structure, saved into the course base of portal netUniversité.

Example of "Branched Exercises" unit of learning

This primary pedagogical model, based on problem solving learning corresponds to the first model presented in table 1. The idea is to present a series of exercises to learners, following a gradual progression of the difficulty level. According to Merrill (Merrill, 2002), learning is facilitated when learners solve a progression of problems that are explicitly compared to one another. Through a progression of increasingly complex problems, the students' skills gradually improve until they are able to solve complex problems. Learning is best when there is a progression of problems to solve and when the problems start easy and then become harder and harder. Elaboration Theory (Reigeluth, 1999) is a model advocating a progression of successively more complex problems. Van Merriënboer's 4C/ID Model (Van Merriënboer, 1997) also stresses the importance of a progression of carefully sequenced problems. Moreover, the path one student follows depends on his performance at the preceding levels.

Figure 13 shows the UML Activity Diagram corresponding to the Branched Exercises unit of learning. The types of learning content involved are online exercises (multiple choice questions, fill in the blanks, free answer etc.).

In this model, the learner must solve the first problem and depending on the answer the system gives him a score. Depending on the score obtained, the learner can solve the same problem (insufficient grade), a similar synthesising problem (good grade) or jump directly to another problem type (very good grade). The cycle is repeated until all exercises have been solved.

It should be noted that the model is at IMS LD level B, because of the use of properties and conditions. We present below a short transcription of this basic pedagogical model in the IMS LD formalism taking into account roles, properties, activities, scenarios and acts as well as the conditions

Roles

There is only one role in the UOL – the learner role, as the answers to the questions are automatically provided, as are the scores and the access to the next exercise level (no need for teacher intervention).

```
<roles>
	<learner identifier="R-Student"/>
</roles>
```

Properties

In order to store the results of the tests, a number of local personal properties are defined:

```
<properties>
	<locpers-property identifier="P-Ex1-Result">
		<datatype datatype="integer"/>
	</locpers-property>
	<locpers-property identifier="P-Ex2-Result">
		<datatype datatype="integer"/>
	</locpers-property>
	<locpers-property identifier="P-Ex3-Result">
		<datatype datatype="integer"/>
	<locpers-property>
	...
</properties>
```

Local personal properties are used, so that their values are set individually for each user and also they are only available for the current run (the value is reset for each run of the UOL and is also not available from another UOL).

Activities

Only learning-activities are present (one for each exercise) since there is no staff role to take support-activities.

```
<learning-activity identifier="LA-Solve-Ex-1" isvisible="true">
          <title>Solve exercise 1</title>
          <activity-description>
                    <item/>
          </activity-description>
          <complete-activity>
                    <user-choice/>
          </complete-activity>
</learning-activity>

<learning-activity identifier="LA-Solve-Ex-2" isvisible="false" >
         <title>Solve exercise 2</title>
         <activity-description>
                  <item/>
         </activity-description>
         <complete-activity>
                  <user-choice/>
         </complete-activity>
</learning-activity>
```

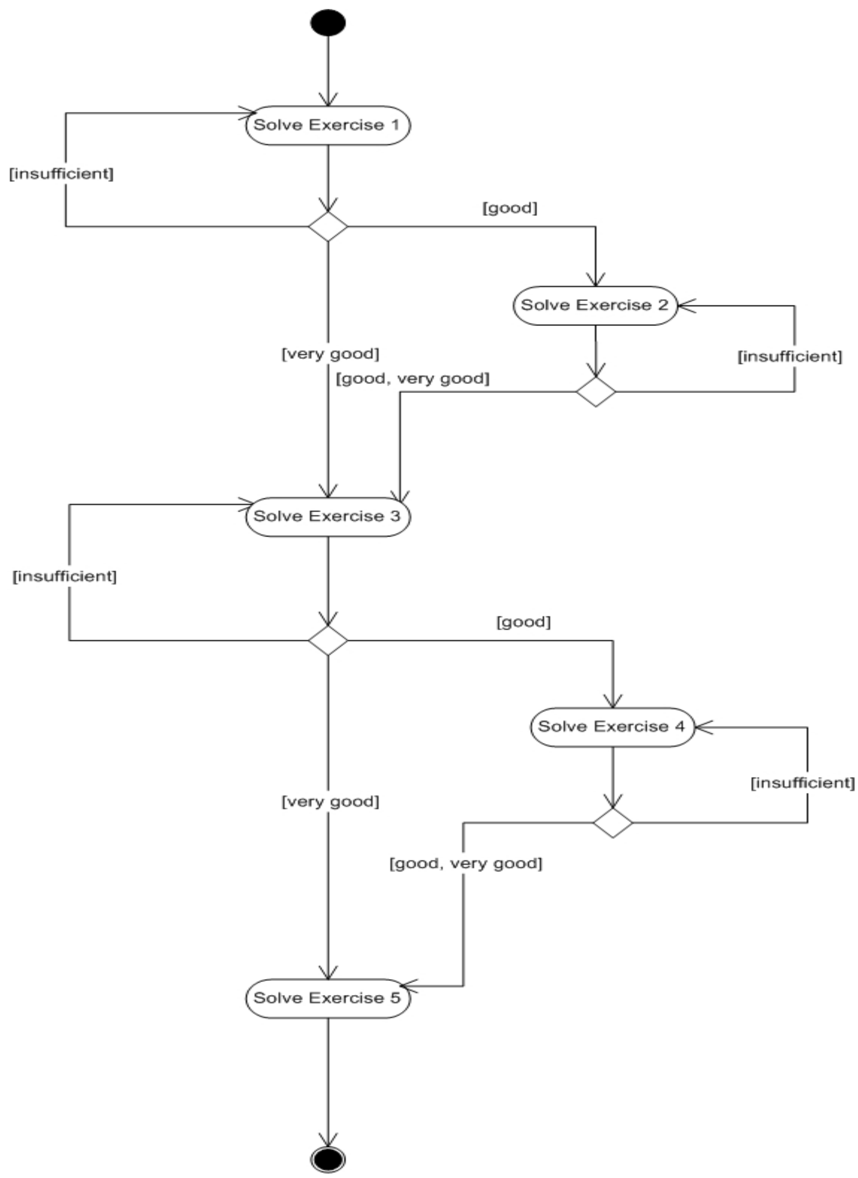

Figure 13. "Branched Exercises" scenario – UML activity diagram

The first learning-activity is the only one visible from the very beginning, the rest being hidden from the user. The learning-activities are all grouped into a single activity-structure of type "selection" (in order to insure appropriate visibility options by means of conditions). All the activities are set to be completed by the learners themselves ("user-choice") in order to provide complete independence.

Plays and acts

This model uses only one play, containing one act, since there is no need for synchronization between students. Thus each student can work in his own rhythm, independent from the other students.

```
<play identifier="Play-Branched-Exercises">
        <title>TD</title>
        <act identifier="Play-Branched-Exercises-a0">
                <role-part identifier="Play-Branched-Exercises-a0-rp0">
                        <role-ref ref="R-Student"/>
                        <activity-structure-ref ref="AS-Solve-Ex"/>
                </role-part>
                <complete-act>
                        <when-role-part-completed ref="Play-Branched-Exercises-a0-rp0"/>
                </complete-act>
        </act>
        <complete-play>
                <when-last-act-completed/>
        </complete-play>
</play>
```

The act is naturally set to "completed" when the corresponding role-part completes, just as the play is set to "completed" when the last act is completed.

Conditions

Conditions in this UOL are used to show the next exercises to the user, according to the results obtained at the previous ones. The adaptability property of the scenario is thus hard-coded into these conditions. The following condition for example, makes sure that the second exercise is made visible to the learner in case he obtained a score between 50 and 79 after completion of the first exercise.

```
<if>
      <and>
            <greater-than>
                  <property-ref ref="P-Ex1-Result"/>
                  <property-value>49<property-value>
             <greater-than>
             <less-than>
                  <property-ref ref="P-Ex1-Result"/>
                  <property-value>80</property-value>
             </less-than>
        </and>
</if>
<then>
        <hide>
              <learning-activity-ref ref="LA-Solve-Ex-1"/>
        </hide>
        <show>
              <learning-activity-ref ref="LA-Solve-Ex-2"/>
         </show>
</then>
```

Positioning of netUniversité in the context of existing LD tools

The netUniversité web portal offers a global tool, integrating a number of other tools such as: a course generator based on a questionnaire (creation from templates), an *editor* for all 3 IMS LD levels (including a graphical interface for editing the IMS LD tree), an IMS LD web *player* for all 3 levels, an administration tool for adding and subscribing students and teachers to courses and an HTML content editor.

The functionality that is out of the scope for netUniversité includes: a constraints editor, the possibility to create UOLs starting from scratch, a way of editing the presentation of LDs, a material repository, advanced testing support (debugging, validity checking, simulations).

A desirable feature is the possibility of importing an already created UOL (whether by the netUniversité editor or by other editors) and also the other way around – the possibility to export a UOL to use with some other player. Providing import/export functionality is an important feature since it would allow reusability and interoperability between platforms, which is one of the main goals of IMS LD standard.

The main difference between the editor integrated in netUniversité and CopperAuthor is that the target users of CopperAuthor are those who have a strong background in the IMS LD standard. Our editor was built especially for users who don't have experience with the specification. Although some of the LD notions were kept, most were renamed and explained, the language of interaction with the users being much more clear and easy to understand. Our IMD LD player has its own engine, basically different from the CopperCore engine.

To sum up, netUniversité is one of the first platforms to support all three levels of IMS LD and the first one to integrate full functionality in a single product, freely available online.

Conclusions

In this article, we presented our research tasks concerning the design and the development of the netUniversité portal integrated in the interactive guide CEPIAH (Design and Evaluation of the Interactive Products for the Human Training). We continued the development of this first version of the prototype by adding functionality for the integration of teaching resources (interactive exercises and tools for communication, personalized according to the types of activities suggested in the generated courses). This new functionality will allow us to generate structures of educational websites based on scenarios that are even more interactive. We think that this interactivity as well as the addition of the tools for communication in the online courses could motivate more students to realize their training tasks.

It is worth mentioning the fact that the IMS Learning Design specification was proposed very recently and netUniversité is among the first platforms to support it. Furthermore, the design of course templates using IMS LD is in its infancy, especially when it comes to levels B and C of the specification. Apart from its novelty, the netUniversité approach also has a sound pedagogical component, reflected in the richness and variety of the learning theories it supports. However, our application has some limitations. The limitations of the proposed pedagogical models first come from the restrictions imposed by the netUniversité platform, namely the simplifications applied when implementing the engine and consequently the player (missing elements such as *set-property*, *view-property*, *set-property-group, view-property-group*, the *class* attribute, the properties of type *file* etc). Another limitation is that it is not possible to reference a UOL from inside an activity-structure, which represents a mechanism for aggregating elementary bricks.

Currently we are in the phase of validating the current version of the prototype with teachers at the UTC as well as the University Aurel Vlaicu in Romania. In a first stage of this experimentation, our goal consists of presenting the netUniversité portal to them and explaining its use. Then, in order to gain their opinions about the ease of use of the system, we ask them to answer an evaluation questionnaire. We are interested to know (after the analysis of the results of the evaluation questionnaires) if the utilization of the two questionnaires (for the pedagogical and GUI aspects) in the process of generation of the course structures encourages them to reflect more on their practices of teaching, but also on the graphical aspects of the interface of their educational websites.

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Complexity of Integrating Computer Technologies into Education in Turkey

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ABSTRACT

Integrating Information and Communication Technologies (ICT) into a centralized education system such as Turkey's depends on its successful design and application, which is an expensive and complex process. The aim of this study was to identify the issues related to integrating computer technologies into a centralized education system. Data were collected from seventeen school principals, fifteen computer coordinators, and one hundred and fifty one elementary education supervisors. The sources of data included semi-structured interviews and a survey. By using content analysis, the following ICT implementation issues were identified: infrastructure, personnel, curriculum, administration, and supervision. By improving these areas, IT classrooms will be more effective.

Keywords

ICT integration, Principals, Computer coordinators, Supervisors, IT classrooms

Introduction

The Context

Turkey's centralized education system began using computers began more than twenty years ago. In 1984, Turkey's Ministry of National Education (MNE) first introduced computers to secondary schools. Then in 1991, national policy included computer-aided instruction. More recently, in 1998, the MNE received a loan, equivalent to 600 million US dollars from the World Bank to invest in a two-phase National Basic Education Program (BEP), which is still being implemented. As a comprehensive educational investment project, the objectives of the BEP are to expand 8-year compulsory education, to improve the quality of education, and to make basic education schools become learning center of the community. In order to improve the quality of Turkey's education, one of the objectives of this development program is to ensure each student and teacher becomes at least literate in Information and Communication Technology (ICT). Phase I was completed in 2003 and Phase II is being prepared for implementation. The phases are described below.

Basic Education Program Phase I (1998-2003)

As ICT initiatives, the following activities were completed within Phase I:

- MNE created 3188 IT classrooms in 2802 elementary schools (K-8) and equipped them with computers, printers, scanners, TVs, videos, multimedia software and slides. All schools had the same number and type of IT tools, except for the number of computers.
- A total of 56,605 computers were distributed to 26,244 rural area elementary schools.
- 1630 laptop computers were supplied to 3000 primary education supervisors who were then trained on computer literacy, active learning, and teaching strategies.
- 25,000 elementary school teachers were trained on computer literacy in various in-service programs provided by the MNE. In addition, 15,928 elementary school teachers received advanced computer training by the contract firms who supplied hardware and software to those schools.
- 2308 computer coordinators were trained on using projectors and 18,517 schools were sent overhead projectors (MEB, 2004).

Since the full implemtation of Phase I has been fairly recent, empirical research reports on the effectiveness of Phase I are limited but all suggest that the IT classrooms are not being used effectively. Akbaba-Altun (2004) explored the school principals' roles related to IT classrooms. In addition, the regulations sent by MNE report that IT classroms are not being used effectively (Reg No: 13, 2002), and suggest some precautions to supervisors and administrators. In another research, Karagöz (2004) interviewed computer coordinators and principals and also found that IT classrooms are not being used effectively. Another research study was conducted with elementary school supervisors by Akbaba-Altun (2005). She reported that elementary school supervisors also observed that IT classrooms are not being used effectively.

Basic Education Program Phase II

Upon implementation of Phase I, Turkey and the World Bank signed a loan agreement for Phase II on 26 July 2002. According to this agrement, the objectives in Phase I were expanded. Within Phase II, preschool education and special education programs were added to the genereal objectives; consequently, the following inititiatives were added to the BEP:

1. Develop an educational web portal site and provide ICT equipment to approximately 3,000 more elementary education schools
2. Provide educational materials to 4000 additional elementary schools
3. Train more teachers, principals and supervisors
4. Continue program implementaion support
5. Continue program progress and evaluation activities.

Integrating computer technologies into education is a large investment that will continue despite research showing that IT classrooms are not being used effectively. Yet, because of the continual large financial investment into ICTs, the question of how can those IT classrooms be used more effectively becomes extremely vital. Understanding the obstacles that have so far prevented effective IT classroom use will not only facilitate the successful implementation of Phase II but will also provide a framework for policy makers to retool the program, raise practioners' awareness toward integrating information technology at their schools, and increase awareness that the ICT issues in culturally different contexts can contribute to Turkey's own understanding of technology transfer. The purpose of this study is to examine the problems and issues in the integration process of ICT from the perspectives of principals, computer coordinators, and supervisors.

ICT use in education: complexity and integration

Educational institutions increasingly emphasize IT as a technical aid in the development of new models of teaching and learning. According to Zandvlift & Straker (2001), IT use is increasing in nearly all facets of life in the developing world and its use is now progressing rapidly in many schools. However, some researchers assert that schools have been slow to adopt such technological change (Todd, 1999; Pelgrum & Plomp, 1991). This contradictory evidence shows that what ICT promises for a community may not guarantee its successful integration into schooling.

The successful integration of technology is not simple because it depends on interlinking variables. In their literature review, ten Brummelhuis & Plomp (1991) describe the introduction of computers in education as a complex innovation in which many obstacles need to be overcome before one can speak of successful innovation. In addition to being time consuming and expensive, technology may confuse, intimidate and frustrate learners and users (King, 2002) resulting in slow adaptation. In addition, educators have additional needs in this learning process as they are urged to immediately and proficiently bring the new learning to significant educational applications in their classrooms. Consequently, successful technology integration depends on overcoming issues with staff development (e.g., Holland, 2001; Cooley, 2001; Swan, Holmes, Vargas, Jenning, Meier, Rubenfeld, 2002; MacNeil & Delafield, 1998), investment in hardware and software (e.g., Casey, 1995; MacNeil & Delafield, 1998), leadership (e.g., MacNeil & Delafield, 1998; Todd, 1999; Leigh, 2000;Turan, 2002; Akbaba-Altun, 2004;), curriculum (e.g., Hakkarainen et al., 2000; Schuttloffel, 1995), teachers' and principals' attitudes (e.g., Casey, 1995; Swan, Holmes, Vargas, Jenning, Meier, Rubenfeld, 2002), and teacher commitment (Schuttloffel, 1995).

MacNeil & Delafield (1998) found that the main inhibitors to implementing technology in the classroom are lack of financial resources for hardware, software, and infrastructure, and lack of time for professional development and planning. Supporting these findings, Pelgrum (2001) asked practitioners from 26 countries what were the main material and nonmaterial obstacles for ICT implementation. Ten most commonly cited obstacles were the following: insufficient number of computers, teachers lack knowledge/skills, difficult to integrate in instruction, scheduling computer time, insufficient peripherals, not enough copies of software, insufficient teacher time, not enough simultaneous access, not enough supervision staff, and lack of technical assistance.

One of the problems with technology integration is the barriers teachers face. In their research, Jenson, Lewis & Smith (2002) summarized these barriers as limited equipment, inadequate skills, minimal support, time constraints, and the teachers' own lack of interest or knowledge about computers. Aduwa-Ogiegbaen & Iyamu (2005) reported the effort of ICT usage and obstacles to use ICT in secondary schools in Nigeria. They claimed the obstacles for ICT use in secondary schools as cost, weak infrastructure, lack of skills, lack of relavent software, and limited access to the Internet. According to Warshauer (2003), on the other hand, there are contradictions between the rhetoric of reform and the reality of school practice. Warshauer (2003) found that technology integration is constrained by political, cultural, and economic factors.

To conclude, in order to improve the teaching and learning processes, both policy makers and practitioners should be aware of the fact that principals, teachers and computer coordinators are the central actors in the implementations of computers' educational practices. Hence, human involment is an essential component of ICT integration.

Methodology

ICT-related studies have mainly applied quantitative paradigms (see, ten Bummelhuis & Plomp, 1991; Hakkarien et al. 2000; Pelgrum, 2001). This study utilized a qualitative framework in collecting and analyzing the data to gather more feedback on the actual success of the programs through the participants' voices. The data were gathered from computer coordinators, school principals, and supervisors.

The Site

This research was conducted in a city at the West Black Sea Region of Turkey. Eighteen schools, of which fifteen were in towns and three were inner city schools, were selected. The distance from the towns to the city centers ranged from 37 km to 88 km. In addition, in order to ensure the reliability and validity of the findings and to observe how common these issues were country-wide, 151 supervisors from 8 different-sized cities (about 10 % of the total cities) from different regions of Turkey participated in this study.

Participants

Since technology integration is a complex process involving many actors, principals' leadership has been described as one of the most important factors affecting the effective use of technology in the classrooms. According to Kincaid & Feldner (2002) administrative modeling seems to be a key to integrating technology. Beside principals, other actors are computer coordinators who are the change agents (Lai, Trewern & Pratt, 2002) and the pioneers of change (MNE, 2001) in the integration process. Supervisors, on the other hand, are the least articulated partners; yet, they help the educational system improve by providing on-going feedback to the system. Consequently, since the primary goal of this initiative was to prepare educators toward technology integration, school principals, computer coordinators and supervisors were the main players in this study.

The participants included 17 school principals, 15 computer coordinators, and 151 primary education supervisors. One central office computer coordinator and one regional representative were asked to participate as key informants since they worked very closely with the computer coordinators and school principals. The selection of key informants was based on purposeful sampling with no gender-specific selection. The logic and power of purposeful sampling lie in selecting information-rich cases for studying in depth. People can learn a great deal about the issues of central importance to the purpose of the research with purposeful sampling (Patton, 1990). By choosing the key informants purposefully selected, the researcher had the opportunity to gather information-rich data.

The majority of school principals in Turkey are predominantly male; therefore, it happened to be all male participants in this research. They come from different educational backgrounds; fourteen of them were classroom teachers, one Religion and Ethics teacher, one Social Studies teacher, and one English teacher. Their job experience ranged from 13 years to 35 years. The average job experience for school principals was 25.5 years with the standard deviation of 6.32 years. Their administrative experience ranged from 2 to 25 years, with 2 to 9 years of computer experience.

The computer coordinators included 13 classroom teachers, one part-time computer programmer, and one graduate of computer education. Their job experiences ranged from 1 to 25 years. They reported to have been using a computer between 3 to 9 years. Most of them also mentioned that their first experience with using a computer started with the BEP through in-service training sessions.

The supervisors were selected from eight different cities. The majority of them were males (90.1%) with work experience between 11 to 25 years. However, a remarkable percent of them (42.4%) had only 1 to 5 years of experience in supervision, while two of the supervisors had a doctoral degree in education.

The central office computer coordinator and the regional representative were the key informants in the study. The central office coordinator, K.A., was working at the National Education Directorate. He has been working as a computer teacher since 1988. After 1990, he began installing computer labs in public schools. Mr. K.A. was selected as a key informant because he works closely with computer coordinators and school principals.

The regional representative, T.A., was responsible for technical maintenance and assistance as part of the warranty for the IT equipment. Another key informant, the regional representative, was mainly responsible for providing support for computer coordinators. This support included repairing and maintaining the equipment and providing software. He was responsible for four other cities in the region.

Data Collection

The data were collected from March 2003 through July 2004 from various city centers. The primary sources of the data included semi-structured interviews, and a survey instrument. The interview data was gathered from principals and computer coordinators in one city, which had 18 IT classrooms in various districts. Supervisors from eight different cities were included in the survey data.

During the interview, principals and computer coordinators were asked the following:
- Could you please explain the IT implementation process?
- What kind of problems happened at your school related to IT classrooms?
- What kind of problems you observed/faced or experienced after IT classroom implementation?
- What else would you like to add?

The majority of the participants allowed tape recorder use. When a tape recording was not permitted, notes were taken. Interview sessions were held with school principals in their offices and, in their classrooms with the computer coordinators. The interviews with key informants were conducted at the researcher's office. Each interview took about 25 to 35 minutes and was tape-recorded. Supervisors answered two open-ended questions which were, (1) What kind of problems you faced/observe related to IT classrooms? and (2) Is there anything else you would like to mention/add?"

Data Analysis

Interviews were audio taped and regularly transcribed. Data were indexed, labeled, and coded according to the major topics. The data were analyzed by content analysis. By using the content analysis, the discourse was systematically observed based on various coding categories. While doing content analysis, first, data were read many times to ascertain any patterns. A matrix was developed according to the given answers to each question. In order to understand the general category, open coding was used. Furthermore, in order to see the related sub-categories, axial coding was applied. Finally, the major issues that emerged from open coding were related infrastructure, personnel, curriculum, administration, and supervision (See Figure 1). These categories and their sub-categories emerged from axial coding are presented as data display in the findings section (See Figure 2).

The following coding scheme was applied on analyzing the data: CC for computer coordinators and P for Principals, followed by the participant row number. For the supervisors, the first letter of their city (K, KN, I, D, DZ, Z, O, E) followed by their row number was used.

Triangulation

Triangulation of sources and of methods was accomplished to ensure the validity and reliability (Patton, 1990). Different sources of data (semi-structured interviews and documents) were compared and contrasted. In addition, key informants were interviewed to validate what informants narrated. Finally, two outside researchers were asked to analyze the same data separately as reviewers. Based on the recommendations from outside reviewers, the data were revisited several times and re-analyzed to ensure agreement among reviewers. In addition, participants' own voices were included in the findings.

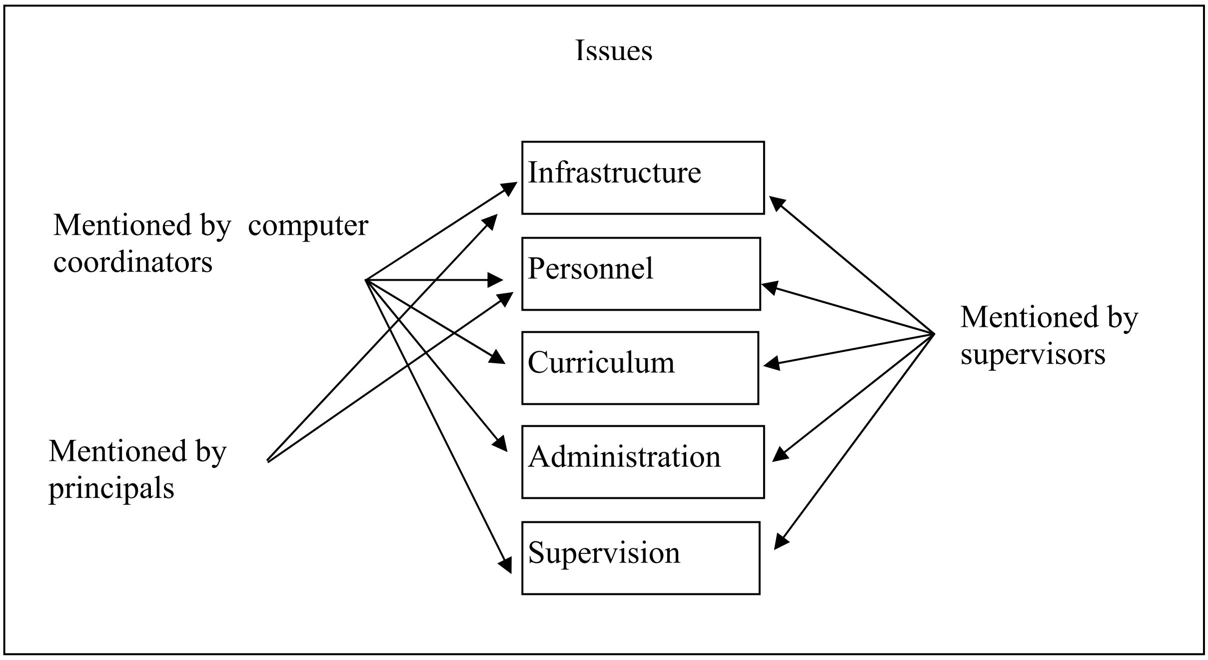

Figure 1. Computer technology integration issues mentioned by principals, computer coordinators, and supervisors

Findings

School principals, computer coordinators and supervisors identified infrastructure, personnel, curriculum, administration, and supervision as main areas of difficulty in IT classrooms. The findings are displayed in the following chart. Each of these categories will be discussed below.

Infrastructure

Infrastructure was the common category voiced by school principals, computer coordinators and supervisors as problematic. The identified issues with infrastructure included the physical setting, equipment, breakdowns, security and maintenance.

Physical settings

Schools were not designed with an IT classroom plan when they were built. Therefore, school principals had problems finding a suitable place for IT classrooms from the very beginning of this project. Almost all participants mentioned that IT classrooms are neither large enough nor suitable for students. For example, one supervisor said that "...there are no appropriate physical settings at schools; we have small classrooms with heating, illumination, and cleaning problems (I6)". Several computer coordinators also add that there is a need for a second wide (CC1, CC2) and large (CC4) IT classroom. Supervisors from various school districts recognize the lack of classrooms (for example, D15, K1, E3, E5, E8). These statements indicate that transforming old classrooms into IT classrooms would not be the ultimate solution. When designing new school buildings, these needs should also be considered to ensure better physical environments.

Equipment

One of the issues raised by the participants was the scarcity in the number of computers and computer parts in IT classrooms as can be inferred from following statements.

- "We do not have enough number of computers" (K6,K11,E5,E8, DZ3,O9, P4, P5, CC1 CC2, CC5, CC3, CC9, CC10, CC14).
- "We need replacements for some parts, such as modems" (E7).

- “We need data show and projection panels in classrooms” (CC1, P18).

Another issue regarding to the equipment was the technical support. This support included both computer-related issues and electrical wiring in the building. For example, one supervisor mentions that “electrical wiring in the building was not designed for many computers in the room. Therefore, these issues are inevitable” (KN8). In addition, due to the inconsistencies in electrical current, operating systems in the labs crash (E13) (E14), and they cannot get technical support quickly (O11, CC12). Moreover, school principals mentioned that they could not get them fixed since they did not have an adequate budget (E1, CC1). Consequently, these computers were no longer functional (O11) (Z6).

Security

All participants in this study consider security as an important issue with IT classrooms. Security is also one of the school principals’ responsibilities. This situation leads to anxiety among school principals (e.g., KN5, CC10), and decreases effective use of these classrooms (e.g., P8), especially when a few computers were stolen from the schools.

Breakdowns

When IT equipment breaks down, repair is often delayed. Sending broken materials to the city for repairs takes a long time (two weeks to six weeks). According to the three-year warranty agreement, repairs should be completed within at most five working days; yet, they may take longer due to geographical and weather conditions. As a result, the number of working computers is reduced, often requiring three or four students to use one computer. Schools have to call the warranty firm and ask them to repair the computers or the equipment, otherwise, schools are responsible for the equipment repairs. Because of the warranty agreement, schools have to wait for the firm.

- “Broken parts are not replaced quickly” (E3)
- “Computers get broken all the time. We do not get them repaired quickly” (DZ8)

School principals and computer coordinators are frustrated due to their limited knowledge on dealing with breakdowns. When a defect or failure happens, computer coordinators cannot find anybody around them to help and as a result, they call the central office for help. Due to the computer coordinators’ lack of technical knowledge and their feelings of incompetence, most of the time they do not understand what the person on the phone says from central office.

> “When problems occur, we try to get help on the phone. But, we are not always successful. When we call for help from the central office, they do not want to come here [to the school] since it is far away from them. We sometimes have to send the machines, which inevitably takes some time.” (CC1).

Maintenance

Maintenance refers to upgrading the hardware and software, repairs and need of technical support. Schools are responsible for finding financial resources to maintain those IT tools. Therefore, many chain problems occur since elementary schools do not have their own budget. Consequently, all participants emphasized that integration is not possible without ensuring ongoing support (e.g., Z6, KN9).

Personnel

coordinators and the issues related to other instructors in IT classrooms. On the other hand, “the scarcity of personnel” (E1, E5, E13, KN9, Z11) and the “lack of qualified teachers at schools” (D14, K10, I9) are the two important issues raised by the participants regarding the personnel.

Computer Coordinators

Computer coordinators’ problems are related to the insufficient in-service training they receive, the ambiguity of their basic rights as State employees, and existing heavy workload. Depending on the on-going changes in computer technologies, computer coordinators are seldom invited for in-service training for their professional development. Yet, even if they take the courses, they are problematic. First, the quality of trainers is questionable (e.g., CC5, E1). Secondly, these courses were not designed for adult learners (CC7, KN5). Thirdly, these in-service courses were not geared toward hands-on practice with computers (e.g., CC1, CC7).

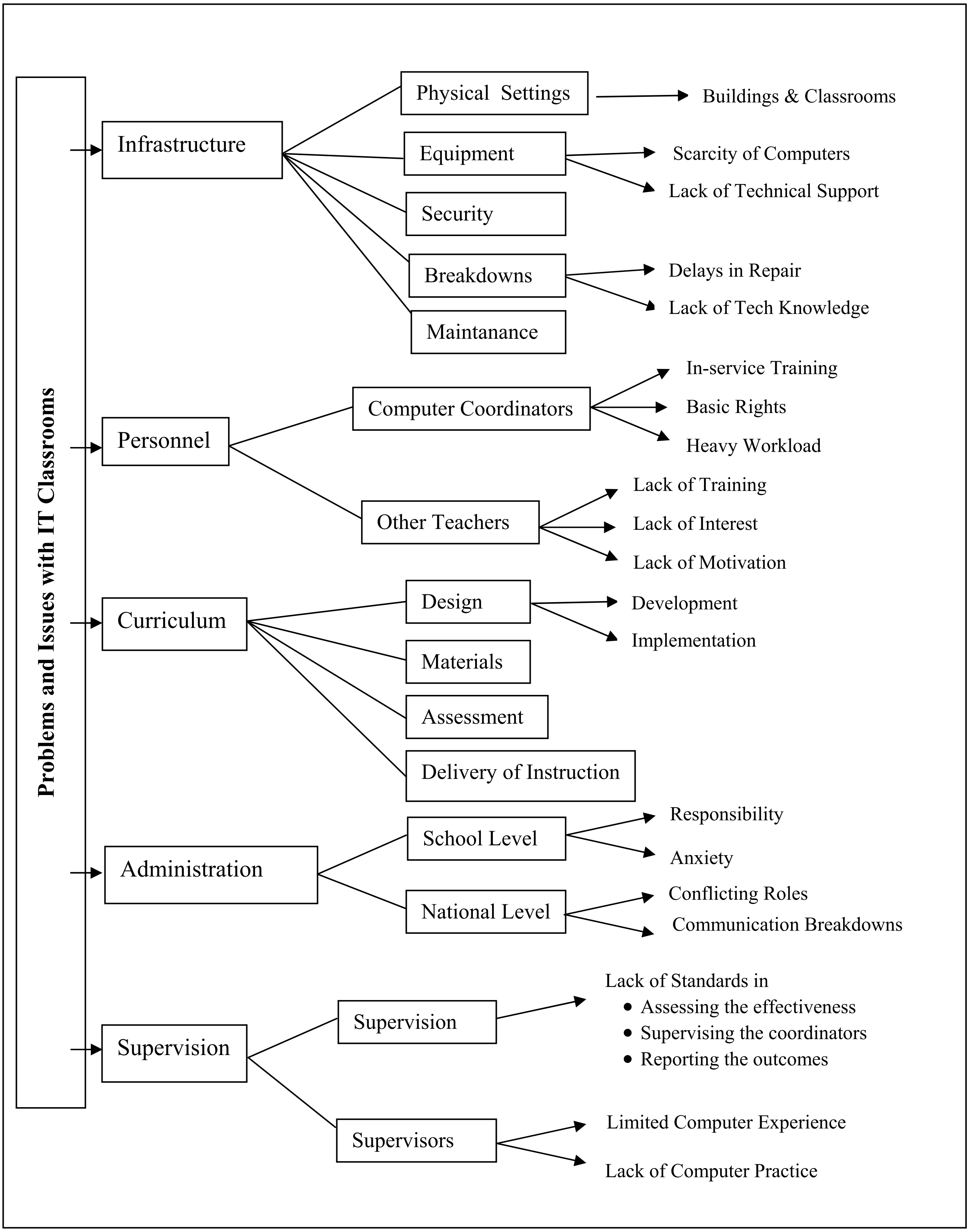

Figure 2. Multi-faces of integrating computer technologies into education

Another problem is related to the ambiguity in basic rights. Computer coordinators were selected among content teachers. Once they start working as computer coordinators, their salaries decrease because they are no longer content area teachers (e.g. CC5, CC6). When schools are in need of content area teachers, the school administration requests computer coordinators to teach their content classes as well. Furthermore, supervisors evaluate computer coordinators' performance according to their field of graduation (e.g., CC3, CC5). Based on this problem, computer coordinators tend to give importance to their content area, rather than valuing their time as a computer coordinator (e.g., CC3, CC6). This conflict in roles also leads to lack of motivation due to not having the same rights as other teachers in the regulations (e.g. CC6, CC3).

Computer coordinators have heavy workloads at schools (e.g., CC1, CC5). In addition to teaching computer courses at schools, they have to plan the IT classroom schedule (e.g., CC1), be responsible for the maintenance of IT classrooms (e.g., CC5), help other teachers to use the computers for their courses (e.g., CC5, CC14), and prepare in-service training for their peer teachers and the public (e.g., CC14, P17).

Other Teachers

The participants also commented on issues related to other teachers in IT classrooms. Lack of interest, technical knowledge, and training are the main issues raised by supervisors, computer coordinators, and school principals.

Computer coordinators complain that teachers are not mutually supportive (e.g., CC5, CC6, CC14). For example, these teachers may not be willing to have individual e-mail accounts by themselves. Computer coordinators go further to add that these teachers expect them to do basic operations for them (e.g., CC14). Such examples clearly indicate that content area teachers do not reflect enough interest in learning to use these technologies.

According to supervisors, some teachers have a lack of technical knowledge to operate these tools in their classes (e.g., D15, I1, O9, DZ4, and DZ8). Consequently, these tools are not being used effectively and integrated into main content areas (e.g., D15, KN9, O7, and DZ9).

Supervisors and computer coordinators point out those teachers did not have adequate training to be able to use these IT tools. Although it is the responsibility of computer coordinators to train those teachers, it is not at all convenient for computer coordinators to do continuous in-house training.

Curriculum

Design

The participants consider curriculum as an important issue both at the development and implementation levels. Computer coordinators and supervisors agree that students' needs were not analyzed well during curriculum development. Hence, the curriculum content overlaps between grades, causing the lack of motivation and interest of students. This also brings up another issue for instructors at the implementation level, since they teach the same content over the years to the same students. The following statements summarize what computer coordinators and supervisors see as problems:

- Students' needs were not considered and analyzed thoroughly (e.g., CC11).
- The content for 4th, 5th, 6th, 7th, and 8th grades is identical. Since we need to keep up with the official curriculum, we find ourselves repeating the same thing every year (e.g., CC5).
- The curriculum should be redesigned, because the framework is the same for 4th graders and 8th graders (e.g., E5).

Materials

Schools have been provided software and videocassettes, in addition to the hardware tools in IT classrooms. Yet, these materials constitute another issue for schools. Firstly, most software titles are designed in English; therefore, instructors cannot use them in their classes. For example, one of the computer coordinators observed that, "The medium of instruction in software programs makes it difficult for my computer coordinators, since they are not good at English" (CC1). Another computer coordinator noticed that only English language teachers use these programs whereas the others refrain from using them (CC5).

Secondly, the selection of CD titles does not match with other content curricula. The schools were provided CD programs for Kindergarteners, 4th graders and 5th graders; yet, there are no software programs for 6th, 7th and 8th graders (CC1). A supervisor raised this issue when he said, "There is a lack of quality and content covered in the software programs. These issues make it difficult for teachers to use them in their classrooms" (e.g., KN10, KN16). Videocassettes, another valuable resource in IT classrooms, are also considered to be an issue in the schools. Most of the videocassettes had dubbing problems. Both Turkish and English voices were overlapped, which lowered the sound quality (e.g., CC5, CC1).

Assessment

One of the issues related to curriculum is assessment. Assessing student level of computer use was considered problematic by supervisors. According to supervisors, there is a gap in curriculum since the goals and objective were not clearly stated (e.g., I8, E8, CC11). Consequently, there are not established criteria or standards to assess students' level of computer use (e.g., E4). Although this issue is directly related to curriculum, it was not included in the curriculum.

Delivery of instruction

The nature of computer courses creates problems for the effective delivery of instruction. First of all, the total amount of time devoted to these courses is limited to two hours a week as an elective course (e.g., DZ3, O4). Secondly, overcrowded classrooms in which there is only one computer per 3-4 students, makes it difficult for instructors to deliver instructions and manage the classrooms. These issues led instructors to focus on delivering theoretical information rather than allowing students hands-on practice. Thus, this information cannot be transformed into practical use (O9).

Administration

School level issues

Administrative issues were mainly raised by supervisors and computer coordinators. These issues are related to levels of responsibility and anxiety. Administrators have certain IT roles, assigned by regulations from the MNE. However, when administrators perform these roles based on their experiences rather than based on the regulations, they cause other problems in schools (for example, CC1, CC12, D9, KN12).

- We have problems since school principals do not have enough knowledge about computers (CC12). When we ask for something, we are often neglected since she/he does not understand its importance.
- Some school principals perceive IT classroom as a burden on their shoulders (D9).
- Since school principals act unwillingly toward IT classrooms, they fail to motivate students and computer coordinators to use the IT classrooms (E8, D9).

School principals feel anxious about the IT classroom materials in their schools. All these expensive materials are the responsibility of school principals if they were stolen or broken. Consequently, school principals tend either to be overprotective and oversensitive or less motivated and less interested in letting others use these materials. Yet, such anxiety causes various issues emerge in the schools.

- When school principals feel anxious about these materials, they keep these laboratories locked and do not open them for use (O9). We have principals who have the fear of breakdowns (D9, E6, O7, and O8).
- Some school principals carry the fear of burglary in IT classroom (D13, KN5).

National Level

MNE is the responsible upper-level organization for policy making and for ensuring IT classroom policies are realized at the school level. Supervisors report that necessary regulations were not carried out on time. For example, official regulations (Regulation #s, 13, 53) were sent to schools in 2001. Yet, the project had started back in 1998 and finished in 2000. Consequently, school principals, computer coordinators, and supervisors were left in confusion with their roles and duties during that period of time.

- Since the organization of IT classrooms was determined by the MNE, the necessary regulations were not received by schools on time (Z7).

Another issue at the national level is the communication one. School principals experience communication barriers due to one-way communication channel, from the Ministry to the school. For example, the MNE wants all schools connected to the Internet, but it does not cover the internet connection expenses. Therefore, school principals feel under pressure.

- Experiencing conflicts between the requests of the Ministry of National Education and schools' own local opportunities. The Ministry of National Education asks school to log on to the Internet and be connected all day, but do not meet the expenses. Due to this problem, schools cannot pay the Internet expenses, and their telephone lines get cut off (e.g., P17, P10, P13, and CC13).
- Since the educational system is centralized, communication flow is usually one way. Sending orders from the Ministry, without a priori knowledge about the issues at schools, creates problems at schools (e.g., CC11).

Supervision

Issues related to supervision were mentioned by supervisors and one of the computer coordinators. These issues can be categorized under two headings: Issues related to supervision and supervisors. At the supervision level, supervisors report that there is not a specific criterion to assess the effective use of these classrooms, supervise the coordinators, and report on the students' work.

1. We have a set of criteria to assess classroom teachers. But, this set of criteria is not compatible with supervising computer coordinators in IT classrooms. We either need a new set of criteria, or to modify the current need (E8, D8, K2, I1).
2. There is not enough time for supervision in IT classroom (KN3, O17).

Supervisors are aware of their limited level of computer use (e.g., D14, E9, E11, and I2) and confess that they are not well-trained to supervise IT classrooms and student work (Z9, KN23, KN11). They go further to add that they have lack of practice in using computers, which is necessary to better supervise computer coordinators (DZ8, E9, KN1).

Discussion and Conclusion

Integrating computer technologies into education requires successful development of infrastructure, personnel, curriculum, administration, and supervision, which can also apply to general education development. These issues are difficult to be separated from general education problems and issues. We can argue that the more problems and issues general education has the more problems and issues we are to face in computer integration. Consequently, there needs to be an integrated organizational approach, where every level of the central organization shows a collaborative effort in integrating computer technologies into schools.

The findings of this study suggest that there are too few computers, slow Internet connections, insufficient software in the native language, and a lack of peripheral equipment at schools. Investment in hardware and software is also mentioned by Casey (1995) and MacNeil & Delafield (1998) as computer integration issues. ICT investment is important initial step as mentioned in the literature.

The IT classrooms at schools were placed in existing older classrooms that were not designed according to the needs of IT classrooms at schools. Future schools should be designed with adequate wiring, ergonomics and security in IT classrooms.

Another finding of this study indicates that in-service training courses for teachers are insufficient, especially in content areas. The participants indicate that courses are given by unqualified trainers and are not geared towards preparing them according to their needs and levels. These in-service training courses also have a lack of hands-on activities and are not offered for school principals and teachers. These issues were also similar to various studies related to staff development and professional development (see, Holland, 2001; Casey, 1995; Cooley, 2001; Swan et al., 2002; MacNeil & Delafield, 1998).

Curriculum problems generally stem from the available software programs at schools. According to the findings in this study, these software programs were not considered to be suitable for the students' grade levels by the participants. One of the reasons may be that a needs analysis was not conducted prior to sending these materials to schools. Moreover, the suggested curriculum for 4th to 8th graders is almost the same and upper grades do not build upon their knowledge. In addition, since software prices are relatively high, it is difficult for schools to purchase. Except for in English courses, other content teachers do not use multimedia software and videotapes.

Similar curriculum issues are also mentioned in different studies (Hakkarainen et al., 2000; Schutloffel, 1995). Consequently, a nation-wide comprehensive needs-analysis would help decision-makers understand how actual users benefit from these materials; pre-designed handbooks and/or guidelines would also guide actual users on how to benefit from these materials.

School principals' lack of technical knowledge, their interpretations of regulations according to his/her own will, and their lack of support pave a way for the given problems and issues. The principals' technological leadership is an important starting point in integrating technologies into education (MacNeil & Delafield, 1998; Todd, 1999; Leigh, 2000; Turan, 2002, Akbaba-Altun, 2004). In addition, since they mostly do not take necessary precautions at their schools for IT classrooms in particular, computers are not protected against burglary. Providing security is one of the roles of the principals related to IT classrooms (Akbaba-Altun, 2004).

Supervisors are in a position to have a significant effect on improving the educational system by providing feedback from the schools to the Ministry. The findings of this study indicate that supervisors do not consider themselves as competent enough to be able to supervise IT classrooms. There needs to be a priori training and support before supervisors are sent to schools. Moreover, more empirical research and case studies are needed to better understand how supervisors can provide effective supervision.

Integration of computer technologies into education is a reform in the Turkish education system which is aiming at leading toward a knowledge society. However, without providing well-planned and up-to-date training programs for supervisors, school administrators, computer coordinators, and teachers, this process will continue to be problem-ridden. Although there is a rich source of literature on cross-cultural experiences about IT integration (i.e., Hakkarien et al., 2000; Pelgrum, 2001; Warschauer, 2003; Aduwa-Ogiegbaen & Iyamu, 2005), further studies aiming at bringing solutions to these problems and issues in computer technologies integration would definitely contribute to our understanding of best practices in technology infusion. Moreover, each issue should carefully be examined from cross-cultural perspectives to further suggest a schematic framework for policy makers and practitioners.

Investment in human capital is as important as investment in technology. The findings of this study suggest that integration technology is not only an investment but also a human resource management issue. To conclude, policy makers need to develop and implement a comprehensive vision and mission in order to minimize problems and issues at school and national levels, especially in those countries with a centralized educational system.

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Context Aware Ubiquitous Learning Environments for Peer-to-Peer Collaborative Learning

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ABSTRACT

A ubiquitous learning environment provides an interoperable, pervasive, and seamless learning architecture to connect, integrate, and share three major dimensions of learning resources: learning collaborators, learning contents, and learning services. Ubiquitous learning is characterized by providing intuitive ways for identifying right learning collaborators, right learning contents and right learning services in the right place at the right time. Our context aware ubiquitous learning environment consists of three systems, namely peer-to-peer content access and adaptation system, personalized annotation management system, and multimedia real-time group discussion system. Since the effectiveness and efficiency of ubiquitous learning heavily relies on learners' surrounding context, in this paper, we will address a context model and context acquisition mechanism for collecting contextual information at run time. We have built a context aware ubiquitous learning environment and in this paper we will address how this newly designed environment can fully support the needs of peer-to-peer collaborative learning.

Keywords

Ubiquitous learning, Context aware, Peer-to-peer, Collaborative learning

Introduction

Various learning systems have been developed in the past decade; the majority of these systems are implemented either with client-server architecture or are centralized server based. The client-server and centralized server approaches are metaphors of student-teacher and repository centric which reflect real world learning scenarios in which teachers act as the content producers while students act as the content consumers.

The ubiquitous learning environment provides an interoperable, pervasive, and seamless learning architecture to connect, integrate, and share three major dimensions of learning resources: learning collaborators, learning contents, and learning services (Chang, & Sheu, 2002; Cheng, et. al., 2005; Haruo, et. al., 2003). Ubiquitous learning is characterized by providing intuitive ways for identifying right collaborators, right contents and right services in the right place at the right time based on learners surrounding context such as where and when the learners are (time and space), what the learning resources and services available for the learners, and who are the learning collaborators that match the learners' needs (Ogata, & Yano, 2004; Zhang, Jin, & Lin, 2005; Takahata, et. al., 2004). As a result, the effectiveness and efficiency of ubiquitous learning heavily relies on the surrounding context of learners. We define the term "context" from two perspectives, one is from the learners, and the other is from the learning services. From the learners' perspective, context is defined as the surrounding environment affecting learners' Web services discovery and access, such as learners' profiles and preferences, the network channels and devices learners are using to connect to the Web, etc. From the services perspective, context is defined as the surrounding environment affecting learning services delivery and execution, such as service profiles, networks and protocols for service binding, devices and platforms for the service execution, etc. Typical learning services for ubiquitous learning are device and network detection services; location tracking services; calendar and social activities services; and content access services.

Virtual learning communities are information technology based cyberspaces in which individual and collaborative learning is implemented by groups of geographically dispersed learners and providers of knowledge to accomplish their goals of learning. There are no agreements on what constitutes a virtual learning community. However, it has gained widespread acceptance that virtual learning communities are knowledge based social entities where knowledge is the key to their success (Bhatt, 2001; Malhotra, 2000). An important activity in a virtual learning community is the collaboration. Many virtual learning communities strive to attract new members or encourage members to learn and to contribute knowledge. However, the knowledge per se does not assure the success of virtual learning communities. It is the collaborative efforts made by the learners and collaborators to manage the knowledge, to enrich the knowledge reservoir, and to help each other accumulate their knowledge in their domain that is central to the continuous growth of the virtual learning communities.

Collaboration in virtual learning communities characterizes itself by heavily relying on interaction among the collaborators (Edwards, 2002; Biström, 2005). The collaborators can be instructors and learners, the interaction can be resources discovery, access, and sharing, as well as group communication and discussion, or simply any collaboration which has occurred among the instructors and learners. In addition, the collaboration should be enacted inside and outside of classrooms without limitation of space and time; it can be over the Internet and beyond the geographical boundary. Nevertheless, such collaboration environment is generally not supported by conventional learning environments. Typical learning services for collaboration in virtual learning communities are content, access of certain learning subjects; making studying notes and annotation on learning subjects; group discussion, brainstorming for knowledge creation and sharing.

Compared with the client-server and centralized approaches, peer-to-peer network makes each peer play as both client and server (Aberer, 2002; Li, Lee, & Sivasubramaniam, 2003; Gnutella, http://www.gnutella.com/), so each peer can access and be accessed of material maintained on the peer If a peer cannot find the material it required from its neighbors, the neighbors will query their neighbors for more resources, in such a way, the peer-to-peer network can find resources in a layered multicast to increase the hit rate of finding materials that peers want. In addition, due to progress of device and communication technology, we can now implement peer-to-peer network under any network channel., This make peer-to-peer network particularly suitable for implementing ubiquitous learning environments for collaborative learning (Brase, & Painter, 2004; Nejdl, et. al., 2002; Biström, 2005; Edutella, http://edutella.jxta.org/).

Context Model and Context Acquisition for Ubiquitous Learning Environments

Context is referred to as any information that can be used to characterize the situation of an entity where an entity can be a person, place and a physical or computational object (Schilit 1994). There are many research efforts for the development of context aware toolkits including; Cooltown (*http://www.cooltown.com/cooltown/index.asp*), Context Toolkit (*http://www.cs.berkeley.edu/~dey/context.html*) and CB-SeC framework (Mostefaoui, Bouzid, & Hirsbrunner, 2003). These toolkits either provide functionalities to help service requesters obtain services based on their contexts or enable content adaptations with user's contextual information. Several OWL-based context models are presented (Khedr, & Karmouch, 2004; Khedr, 2005) to provide high-quality results of service discoveries beyond the expressive limitations of CC/PP. They utilize ontology to describe contextual information including location, time, device, preference and network etc. By combining semantic contextual information with inductive or deductive techniques, they can perform matches against both user and service's context semantically. In contrast, our approach not only provides an ontology based context model but also utilizes three context acquisition methods namely; form filled, context detection and context extraction, for obtaining various contextual information. Besides, we also employ a rule-based matching algorithm with truth maintenance to enhance the recall and precision of context aware service discovery (Yang, Tsai, & Chen, 2003).

Context Description

We conceive context aware is an interactive model between learners and services, thus, we need to address the context description of learners and services. We have developed two types of context ontology for describing learners and services, they are learner ontology and service ontology (Yang, et. al. 2005).The interactive model is enacted by a semantic matchmaker that can perform semantic reasoning for context oriented service discovery and access based on the two context ontology.

We have utilized Protégé (http://protege.stanford.edu/) to build the learner ontology and service ontology as shown in Figure 1.

The major difference between the learner ontology and service ontology are their profiles. The learner ontology contains learner profiles such as personnel profile, accessibility and preferences, calendar profile, social profile, and location profile; The service ontology contains service profile such as input, output, pre-condition, and effect of service execution.

In addition to profiles, both learner ontology and service ontology contains surrounding context such as quality of learning service, environment profile, and device capability profile. Quality of learning services profiles (QoLS) contain functionally and non-functional QoLS constraints; Functional QoLS constraints can be described by network bandwidth and response time; non-functional QoLS constraints can be described by reliability, availability, and cost. Environment profile contains network channel constraints and situated location constraints; Network channel constraints can be used to describe types of channels such as wired or wireless; situation constraints can be used to describe requester situated environments such as in a meeting, reading, walking, or driving. Device profile contains the device's hardware and software constraints. Various devices such as PDA and mobile phones are equipped with different hardware and software constraints. Hardware constraints can be used to describe device hardware capabilities such as platform, CPU speed, memory size, screen size and resolution. Software constraints can be used to describe device software capabilities such as operating system, browser, playable media type and resolution.

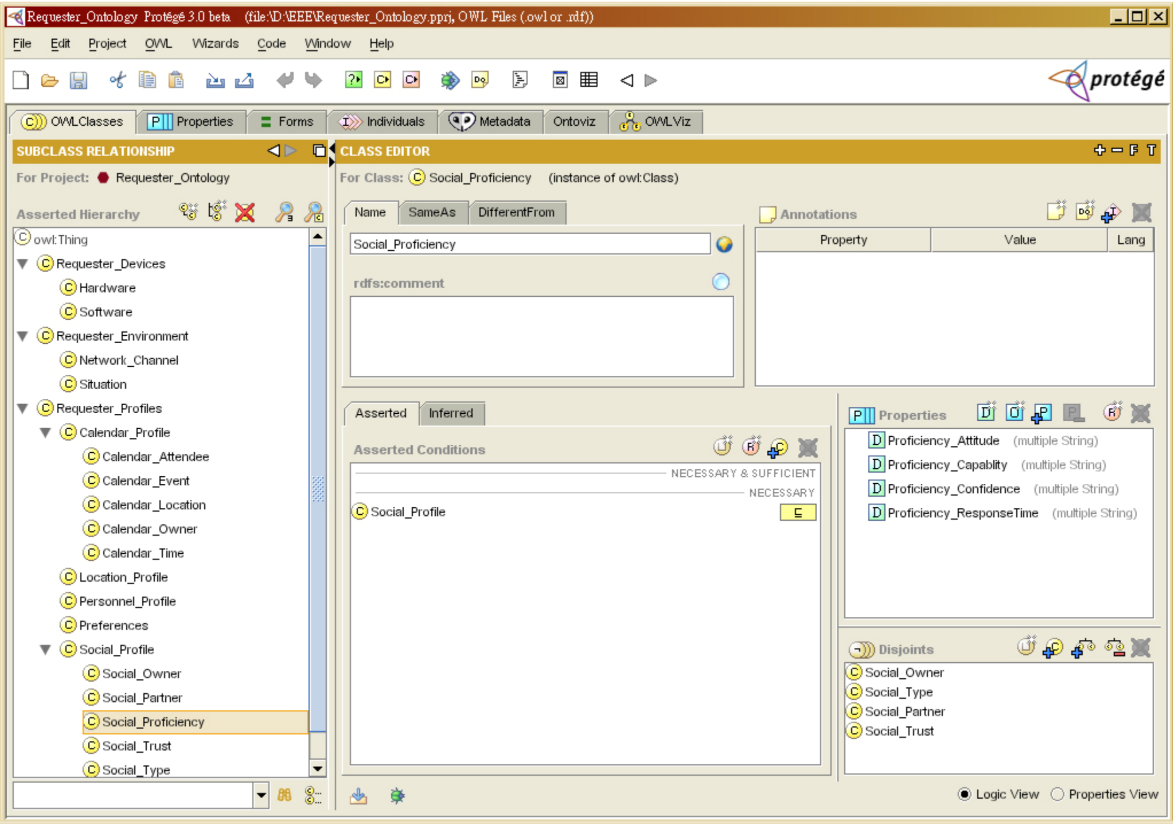

Figure 1: Learner ontology editing with Protégé

The formal definition of learner ontology is defined as follows:

Learner ontology = {Profiles, Preferences, QoLS, Environment, Devices}
Profiles = {Personnel, Calendar, Social, Location}
Personnel_profile = {name, role, ID, phone, address, email, accessibility}
Location_profile = {office, building, home, out of office}
Calendar_profile = {owner, event , time, attendee, location}*
owner = {name, ID, privacy}
event = {title, description}
time = {begin(yyyy:mm:dd;hh:mm), end(yyyy:mm:dd;hh:mm)}
attendee = {name, contact_info}
location = {place, contact_info}
Social_profile = {owner, collaborator+}
owner = {name, ID, privacy}
collaborator = {profile(type, name, context_info), proficiency, trust},
type = {individual | working_team | community}
proficiency = {capability, confidence, attitude, response time}
trust = {reliability, experience, referral network}
Preference = {default device, default environment, default QoLS}
QoLS = {Functional requirement, non-functional requirement}
Functional requirement = {bandwidth, response time}
Non-functional requirement = {reliability, availability, cost}
Environment = {Network channel, Situation}

Network channel = {wired, wireless} *Situation = {normal, meeting, walking, talking, driving* *Devices = {Hardware, Software}* *Hardware = {platform, CPU, memory size, screen resolution}* *Software = {OS, browsers, playable media types}*

The formal definition of service ontology is as follows:

Service ontology = {Profiles, QoWS, Environment, Devices} *Profile = {name, ID, description, input, output, pre-condition, effect}* *QoWS = {Functional requirement, non-functional requirement}* *Functional requirement = {bandwidth, response time}* *Non-functional requirement ={reliability, availability, cost}* *Environment = {Network channel, Situation}* *Network channel = {wired, wireless}* *Situation = {normal, meeting, walking, talking, driving}* *Devices = {Hardware, Software}* *Hardware = {platform, CPU, memory size, screen resolution}* *Software = {OS, browsers, playable media types}*

Context Acquisition

Knowing learners' surrounding context in a ubiquitous learning environment is referred to as context acquisition. Context acquisition can be realized by a process of getting values of the properties defined in the learner ontology and service ontology. We classify context into current context and past context; the current context reflects the run time environment while the past context reflects a historical execution path. Context acquisition is mainly for detecting current context. When new context has been detected, the current context will become past context and storage as learner ontology. As a result, we can treat learner ontology as a set of past context which can be used for deriving preferences, portfolio, and behavioral patterns.

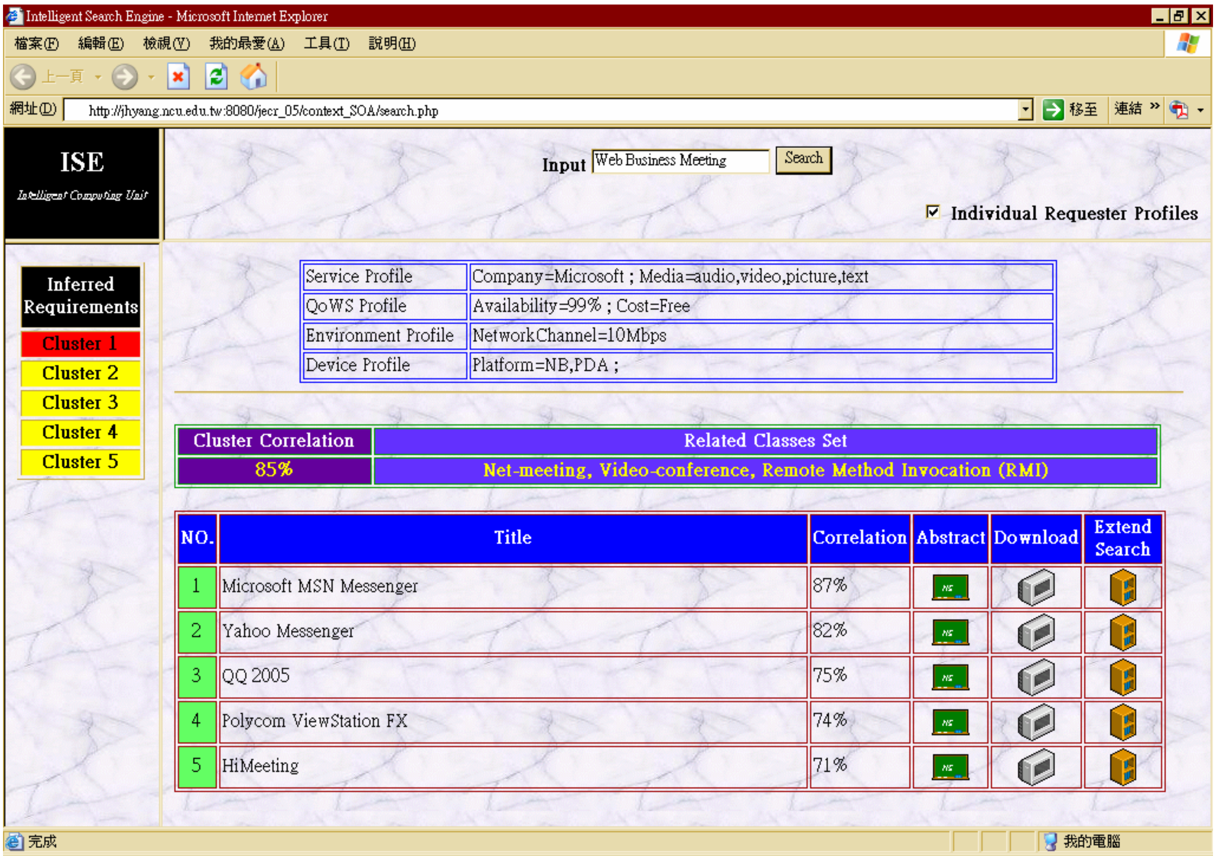

Figure 2: A query user interface for requesters to input their query in terms of keywords

We then separate the context acquisition function from context aware services. This strategy leverages our load by reusing existing context acquisition functions. Context acquisition can be done by three approaches. The first approach is through filling in a form in which context is acquired directly from learners' inputs. The second approach is context detection in which we utilize various sensing, recording, and positioning systems such as GPS, RFID, and sensor networks for location detection. The third approach is context extraction which is to derive contextual information from learner personal ontology and service ontology. The first approach in filling in a form is mainly used to construct personnel profile, preferences, calendar profile, and social profile. Since this approach is self explanatory we will concentrate on the other two approaches, context detection and context extraction.

Context Detection

Context detection is a two-fold mechanism, we need to tackle this from two sides, one is from the server side, and the other is from the client side. From the server side, we have implemented a Web service portal featuring a recording capability as shown in Figure 2. Whenever learners log in to the portal, our portal will take the request and analyze what kind of device the learner is using to build the device profile, as well as detect what kind of network channel the learner is connecting to the Web to build the environment profile. Whether the learner is in a meeting, driving or a normal situation remains unknown at this stage; we need to defer this to context extraction by analyzing the learners' calendar, social and location profiles. Besides detecting the request, our portal also records and keeps a service request history associated with every learner who registers in this portal. Based on the history, we can conduct analysis about the requesting behaviour and requesting pattern which are important references for building learners' preferences.

Figure 3: Smart device with content adaptation capability

From the client side, we have utilized smart devices with content adaptation as shown in Figure 3 and sensor networks to sense and react to the learners' surrounding environment. Almost any information available at the time of an interaction between learners and Web systems can be seen as contextual information such as location and temporal information, knowing where is the learner and what he/she is doing during a certain period of time, whom you are working with, and people that are nearby, resources that are nearby (e.g. accessible devices, and hosts), etc. We are interested in capturing and modeling the contextual information, and how a part of this contextual information is assembled, organized, and structured into learner ontology. Such contextual information is used to design adaptive systems and to provide customized services to learners based on their profile and preferences.

In location tracking services, we will match all possible location tracking functionalities currently available for learners' devices, then filter them based on learner's context. For example, if the learner is outside of a building, then a GPS location tracking function will be invoked to return his/her location in terms of building name/number; while the learner is inside a building, then indoor tracking system (RFID or sensor network) will be invoked to return the location in terms of room number. Once the location is positioned, we will decide whether to disclose the location based on the learner's privacy preference. Please note, the privacy preference is dynamic and can be adjusted based on location and temporal constraints. For example, if the learner is inside an office building, then he/she is willing to disclose the room number where he/she is currently is to the public, while if the learner is out of office, then the position is only disclosed to his colleagues and family members.

Context Extraction

If we can not detect current context explicitly, then we will need to extract from the learner's profiles to derive contextual information associated with the request. Context extraction is used to derive contextual information from learners' preferences and profiles during the run time. There are two approaches to context extraction. One is to extract learner's default context from the preferences and personnel profile. The other is to extract derived contextual information from the calendar profile, social profile, and location profile.

In the first approach, the learner must specify their values such as name, ID, role, email, etc in the required properties because many properties defined in personnel profile and preference have default values and as a result, our system will fill in the default value for the learners if they do not explicitly specify the property values. We refer this kind of process as context wrapping.

In the second approach, we derive contextual information from calendar and social profiles. Social profile is used to find the most related business partners when the learners have not explicitly specified whom he/she is working with. Social profile is also useful when the learner can turn his/her calendar profile to private and you just need to find him/her no matter how. This can be done by querying every partner's calendar profile to find if there is any event involving the target person.

With our calendar extraction, we can locate a learner's position and read his calendar and his social profiles knowing where he is now and doing what, as well as knowing whom the learner is currently working with. Therefore, we can provide a context oriented service to better fit the learner's needs.

If we cannot derive proper learning collaborators from learners' social profiles, the alternative way is to locate collaborators from outside. This can be done by querying collaborators from a virtual community for knowledge sharing with certain specific expertise (Yang, Chen, & Shao, 2004). As a result, we need to maintain an expertise profile for this. Compared with the social profile which is mainly kept in the client side, the expertise profile is kept in the mediator side which can be used for locating suitable collaborators based on the learners' social profile. Contextual information derived from the expertise profile is useful when a learner needs to find matching learning collaborators with specific expertise. The collaborators can be an individual, a working group, or simply a community. We have defined properties as matching indicators which will be used to calculate the degree of matching of fit to the learner's need. The property of expertise indicates what the matching expertise is; the property of proficiency indicates the capability, confidence and response time of the business partners based on previous experience and the property of trust indicates the degree of confidence regarding a particular partner.

The formal definition of expertise profile is as follows:

expertise_profile = {expertise, profile, proficiency, trust}
expertise = {title, description}
profile = {name, ID, privacy}
proficiency = {capability, confidence, attitude, response time}
trust = {reliability, experience, referral network}

The degree of proficiency and the degree of trust of partners with a specific expertise can be calculated with the following equations:

*proficiency = (capability * confidence * attitude) / response time* *trust = reliability * experience * referral network*

Peer-to-Peer Collaborative Learning

Based on a study we have conducted at the National Central University to survey the most anticipated services provided by a learning system (Yang, Lan, & Huang, 2005), as shown in Table 1, we found that learners are firstly interested in who is currently on line, secondly, how to get in touch with their classmates or other learning collaborators via instant message and thirdly, how to find the material that learners really need. The fourth is how can learners take class notes and record these notes and scratch as personal annotation for future references while the fifth is how learning portfolio can be recorded for better personalized service when next reconnected to the system.

Table 1: Students' most wanted learning services in National Central University

Most wanted learning services	percentage
who are currently on line	23%
instant message	23%
learning content search	21%
personal annotation	17%
recording of personal learning portfolio	16%

As a result, our ubiquitous learning environment is designed with the students' most wanted services in mind. This environment also consisted of three systems; they are peer-to-peer content access and adaptation, personalized annotation management, and multimedia real-time group discussion systems.

Peer-to-Peer Learning Content Access and Adaptation

The peer-to-peer network makes each peer act as both client and server, so each peer can access and be accessed of material maintained on the peer. If a peer cannot find the material it required from its neighbors, the neighbors will query their neighbors for more resources, in such a way, the peer-to-peer network can find resources in a layered multicast to increase the hit rate of finding the material that the peer wants. There are two types of common communication in peer-to-peer architecture; one is the message exchange, and the other is file transmission. The message exchange is used for finding which peers possess the material the other peer wants, that is, finding who owns the resources. The file transmission is used for downloading or uploading material between two peers. Peer is like a neuron, it will relay/pass message, discovery service advertisement, and each peer is not only a messenger but also a service registry.

In addition to being both client and server, a peer can also be a mediator to refer a query to a related peer node based on the advertisement in its referral bank. The referral can be further classified into mediator peer referral and provider peer referral. The mediator peer is designed based on the "knowing whom to find help for." Our current approach of peer clustering and categorization is to organize peers into a tree structure and cluster similar peers into domain based on property (content provider) and capability (service provider). For example, within a school our peer-to-peer network is organized with an hierarchy of university, college, department, grade, and student which can be modeled by a tree structure.

As shown in Figure 4, each peer in our peer-to-peer network can be a server or a client. It is a registry containing all the semantic and contextual information pertaining to the personal resources. The learning resources are described by contextual profiles including role profile, environment profile, device profile, QoS profile, calendar profile and social profile which are implemented by peer ontology. In addition to the personal profile, learners can also request for public resources provided by UDDI registry.

Free rider is a common symptom occurring in peer-to-peer network (Biström, 2005). The so-called free riders means peers who consume much more than they contribute, for example, removing shared resources; terminating connections while other peers are downloading. We have defined a credit policy to identify a list of free riders and limit their access to the entire peer-to-peer network until they are removed from the free riders list. The credit calculation in this credit policy is based on the ratio of upload over download in terms of connection time, transmission byte and varieties of files. The peer with a higher credit ratio will be granted higher priority for file downloading.

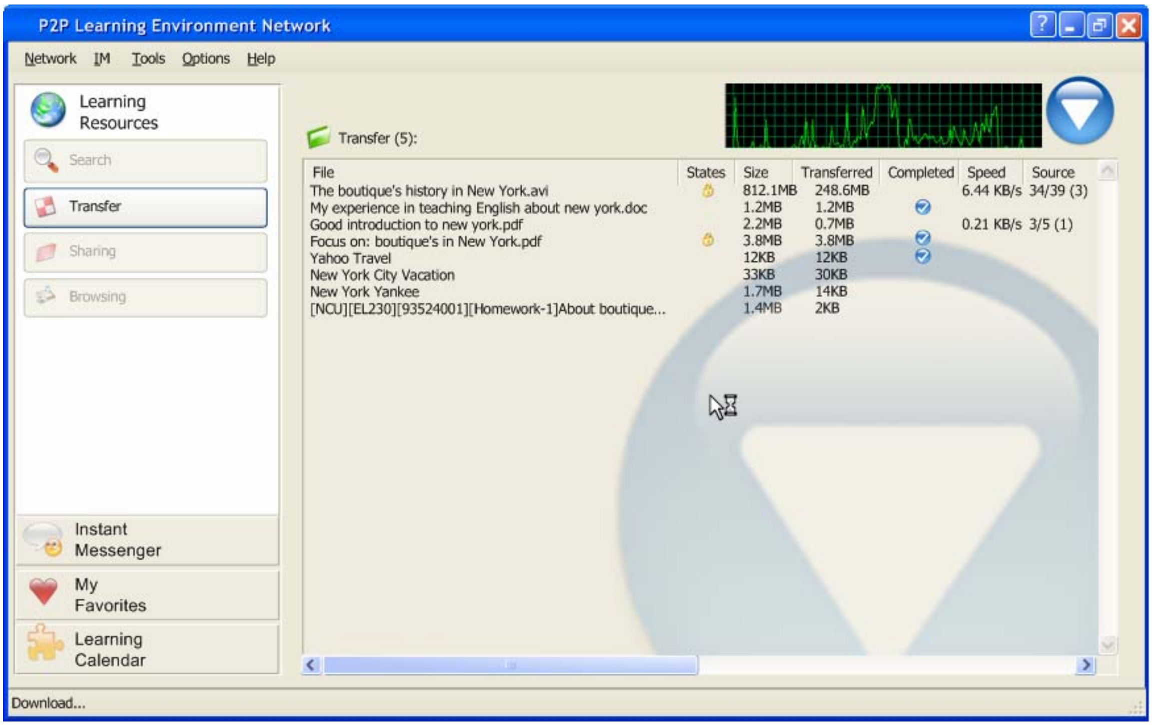

Figure 4: Peer-to-peer network

Figure 5: personalized annotation management system

Our peer-to-peer content access system provides typical services such as content discovery and access, content exchange, content replication, and content synchronization (persistence); services planned to provide a plan if the service request cannot be solved by a single service or by a single peer node: Ontology alignment to perform ontology mapping to reach an agreement of using a common ontology or metadata schema; Query referral to refer a query to other peers if the current peer cannot solve the query; Query transformation to rewrite a query if peers are using common metadata with extension or variation; Peer clustering to cluster peer nodes into a referral network based on their registered capability; Service referral to recommend other peer nodes which are capable or more suitable to provide the requested services; and peer trust management to maintain a trustworthy social network in a peer-to-peer network.

Personalized Annotation Management

From a learners' viewpoint, annotations are not only reminders of things to do, but also concept and thought. The annotated document can be pdf, word, and any web pages in html. Annotators can create their annotations in forms of either text or voice. There are seven types of annotation in our system; they are question, explanation, commentary, bookmark, sketch, drawing, and link. Annotators can choose one of them to distinguish their annotation.

As shown in Figure 5, our personalized annotation management system provides typical services such as the creation and editing of annotation, the retrieval of annotation by query, and knowledge management with annotation.

Multimedia Real Time Group Discussion

Group discussion is another important learning issue in collaborative learning. Gall (1987) mentioned discussion is a process in which a small group assembles to communicate with each other using speaking, listening, and nonverbal processes in order to achieve instructional objectives. Gall also addressed the optimal group size for discussion to be between five and eight participants. Through the discussion, learners can review their ideas and get valuable opinion from another's aspect.

The purpose of group discussion is to form a learning group based on a specific topic for a learning objective. This involves group formation, the mechanism to form a group based on individual knowledge level and capability level as well as interest. There are two approaches of group formation; one is based on the learning objective, the other is learning on demand. For a specific learning objective, group members should have various knowledge and capability levels in order to compliment each other and form a team work. For learning on demand, the grouping is based on certain needs, for example, post a question and looking for help. In this case, the collaborators with certain interests and knowledge are the priority choice.

We are designing our message service from a group collaboration point of view (as shown in Figure 6), that is, to provide message services for group collaboration, such as discussion, instant messenger, message exchange, message filtering, push message, and message synchronization within a group. In our design of group collaboration, each peer is free to initiate a special interest group (SIG) and free to apply to join any SIG initiated by other peers in the peer-to-peer network. The peer who initiates a SIG is the default SIG manager who has the authority to grant a pass to other peers who are interested in joining the SIG.. Typical SIG management includes granting a pass, maintaining the discussion and file sharing which has occurred in the SIG etc.

Our multimedia real-time group discussion system provides typical services such as group formation, email and instant message services for the entire peer-to-peer network, special interest groups, audio and video conference, electronic whiteboard, personal or group calendar services, personal ontology, groups, ontology for ontology management, and session management and synchronization management when peers reconnect to the network.

Illustration and Discussion

In this section, we will illustrate our context aware ubiquitous learning environment with a scenario to demonstrate how the three systems, peer-to-peer content access and adaptation, personalized annotation management, and multimedia group discussion systems we have built in the past few years can help learners in collaborative learning.

A graduate student "Albert," was assigned a project entitled "One week vacation in New York City". He immediately remotely connected to his desktop PC located at his Lab and began to do a peer-to-peer (P2P) search for finding material regarding this project. Albert used a keyword search by typing "New York Vacation," into the P2P system as shown in Figure 7. In order to give Albert the "right content" to fit his needs, our P2P system automatically filtered unrelated material from the keyword search result and left material suitable to Albert. We do such filtering based on Albert's contextual information such as preferences and profiles as addressed in context model.

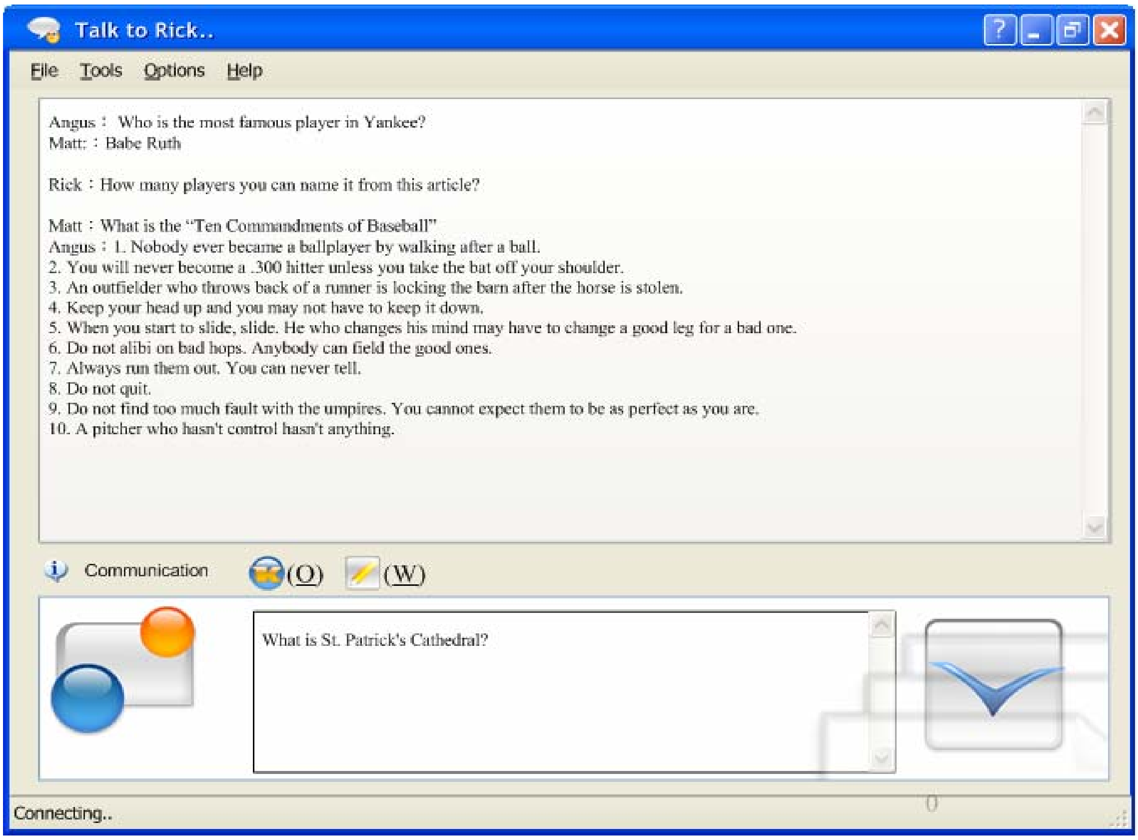

Figure 6: message communication during real-time discussion

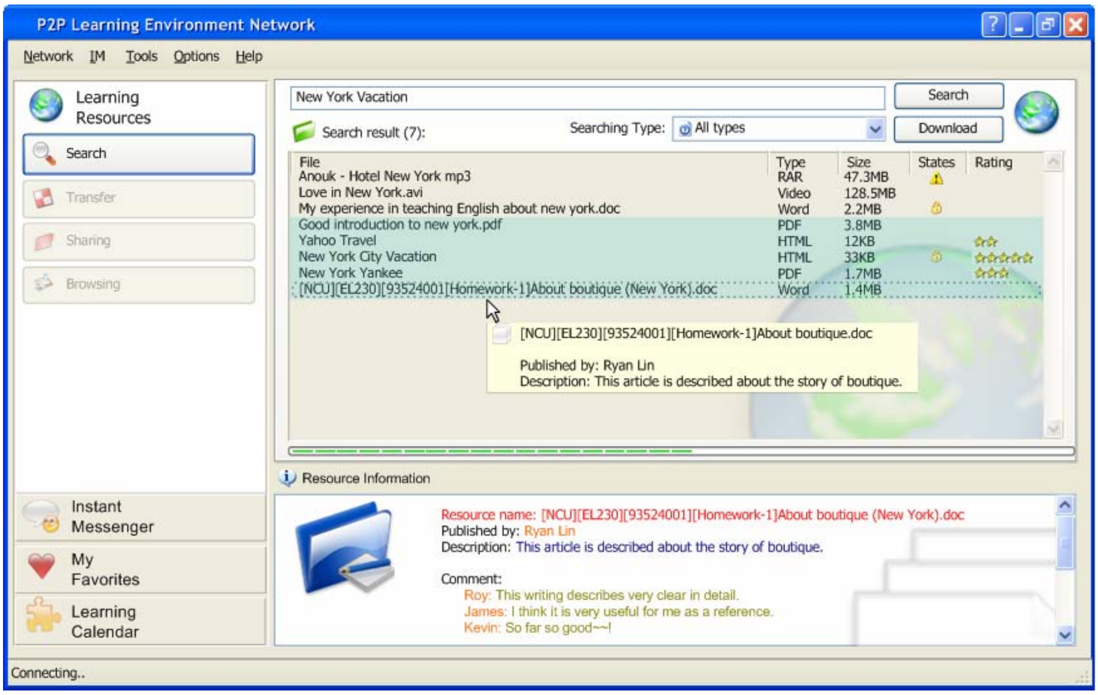

Figure 7: Peer-to-peer content search and its search results

Albert found quite a lot of related material after the P2P semantic search, so he decided to download some. Since downloading is very time consuming due to file size and network bandwidth, Albert decided to have lunch while the P2P network was downloading files. After his lunch, Albert stayed at the Café and talked to his friends. Then he thought it was about time to check the downloading status, so he pulled out his PDA, connected to the P2P network and began to browse some of the downloaded material. Since most of the material is designed for the presentation on PC or NB, our content adaptation system needed to adjust the downloaded material to fit the presentation on PDA. As shown in Figure 8, Albert surfed Yahoo travel pages and browsed the New York pictures with his PDA. This is one way to provide right content on the right device with right presentation. Albert found an article about New York Yankees which was quite interesting, so he decided to go through the details. So far, we have provided a seamless connection and network device detection for finding right content.

Figure 8: Adapted Web content shown on PDA; the screenshots from left to right are Yahoo travel, New York Pictures, and New York Yankees, respectively

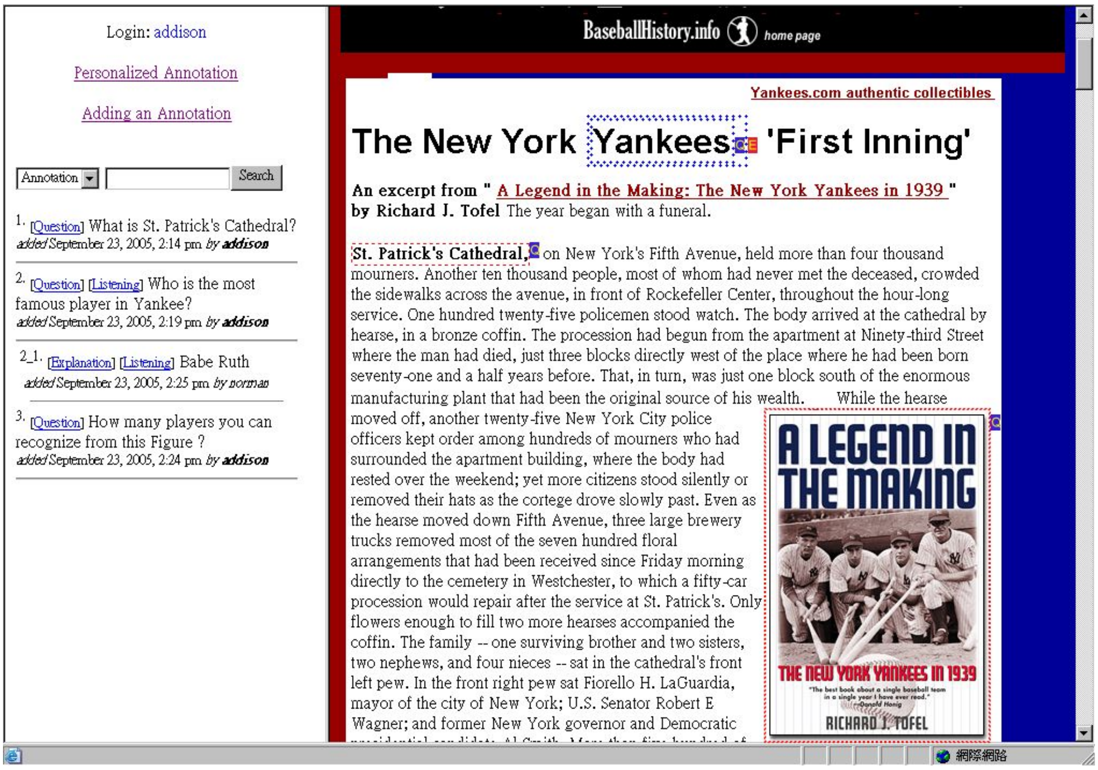

Figure 9: Three annotations of Yankees, St. Patrick's Cathedral, and a Picture

Albert then went to the Library for further studies of the article about New York Yankees. He began to read and make his own notes and annotations with text and voice on this article via our personalized annotation management system. Since Albert is not a native New Yorker, he had no idea of what is St. Patrick's Cathedral, so he annotated as a question, the term “St. Patrick's Cathedral”, which appeared in the article. He continued to make annotations regarding who is the most famous player in the Yankees, and who are those players shown in the pictures on this article as shown in Figure 9.

In addition to making personalized annotation, Albert could also retrieve information such as who else had read or was currently reading this article; find all the annotations made to this article; and find any annotations relating to “St. Patrick's Cathedral” and who made the annotations. So far, we have provided an annotation system to make and find annotations, annotators, and related articles. In addition, this annotation system can help Albert to find peers who share similar interests and knowledge to form virtual learning communities for further collaboration.

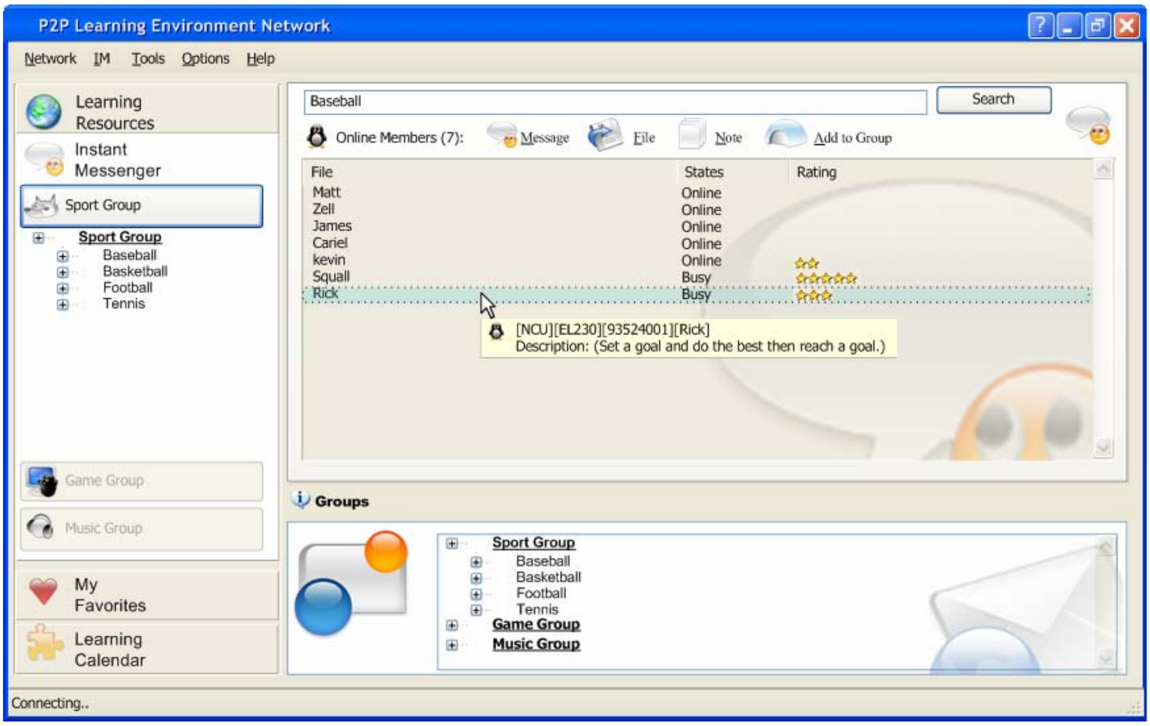

Figure 10: Searching for who is currently on line and available for real-time discussion

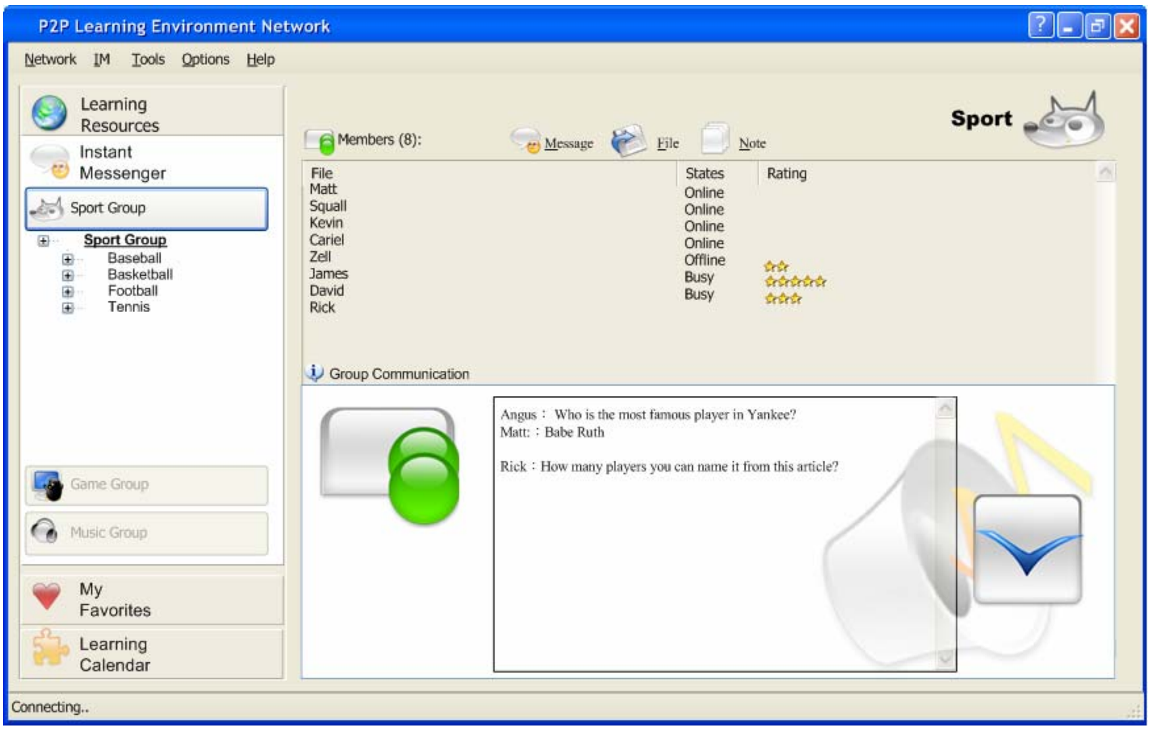

Figure 11: Real-time discussion board

To create more interaction with other peers, Albert wanted to raise a real-time discussion about the term "New York Yankees", and therefore needed to find out who was currently on line and available in his virtual learning community. Through our multimedia discussion system as shown in Figure 10, Albert could search to see if there were other annotators currently on line? Are the authors of this article currently on line? Are Albert's instructor and TA currently on line? Are Albert's Lab mates, class mates, or friends currently on line? Or simply are any peers currently on line. Now Albert could form a small discussion group in his virtual learning community quickly and proceed with a real-time discussion (Figure 11) by using services provided by our group discussion system. Albert could even leave a post-it note to one of his peers who participated in this discussion group as shown in Figure 12.

Figure 12: Leaving a post-it note to peers in the discussion group

Conclusion and future research

In this paper, we have shown a context aware ubiquitous learning environment which consists of three systems, namely peer-to-peer content access and adaptation system, personalized annotation management system, and multimedia real-time group discussion system. Since the effectiveness and efficiency of ubiquitous learning heavily relies on learners' surrounding context in this paper, we also have addressed our context model and context acquisition mechanism for collecting contextual information at run time. Finally, we illustrated a learning scenario and demonstrated how this newly designed context aware ubiquitous learning environment can fully support learners in collaborative learning.

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Providing cultural context with educational multimedia in the South Pacific

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ABSTRACT

A recent research and development project conducted at the University of the South Pacific (USP) examined how educational multimedia can be built according to the learning approaches of the region. Through interviews, questionnaires and usability tests with staff and students at USP, the research team drafted a set of recommendations for the development of educational multimedia in the region. They then built an interactive CD-rom based on these recommendations. This paper focuses on the results related to cultural context, and the directions they indicate for educational multimedia developers in the South Pacific. Specifically, the study found that Distance and Flexible Learning (DFL) materials do not generally provide the cultural context that staff and students desire at USP, as they rarely utilize local metaphors, examples or Vernacular language. The paper presents approaches developed during the project to provide cultural context in two categories: decentralised and dialogic contextualisation. Through decentralised contextualization tools such as a Wiki or digital scrapbook, students are encouraged to provide their own cultural context to the learning materials. Dialogic contextualisation tools such as virtual peers and interactive quizzes can provide cultural context in a more conversational, personified, and centralised manner. These ideas are illustrated with specific examples of educational multimedia projects, so that they can be easily replicated and modified by educational multimedia developers in their own contexts.

Keywords

Cultural pedagogy, Educational multimedia, South Pacific, Distance learning, Contextual learning

Introduction

As a regional University serving 12 island nations scattered over 33 million square kilometres of ocean, the University of the South Pacific (USP) teaches to a widely distributed region with a variety of cultures. Consequently, students' coursework is often divorced from their own home cultures (Thaman, 2000a). Many lecturers and course books come from abroad, English is a second language (or third, or fourth) for most students, and the formal educational system itself was imported from another part of the world (Matthewson, 1994; Thaman, 2003a; Wah, 1997). Bridging this gap between the culture of largely imported educational institutions and the cultures of their students has been a major focus for Pacific educationalists (Lockwood et al., 1998; Thaman, 1997; Va'a, 1997, 2000; Wah, 1997).

In a recent research and development project, the USP Media Centre explored how educational multimedia can help bridge this cultural gap. Through questionnaires, interviews, and usability tests with students from the twelve member nations of USP (Cook Islands, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu), and a review of regional academic literature, the research team mapped learning approaches of students in the South Pacific to the development of educational multimedia in the region. Key aspects of regional learning approaches raised during this process include modeling (Jordon et al, 1981 in Taufe'ulungaki, 2000; Thaman 1999; Va'a, 1997), trial and error (Mel, 2001), vernacular language (Pagram et al., 2000; Taafaki, 2001; Taufe'ulungaki, 2000), preserving the whole (Harris, 1992; Thaman, 1992; Yorston, 2002), increasing complexity through successive approximations (Harris, 1992), and cultural context (Okamura & Higa, 2000; Taufe'ulungaki, 2000). Based on these findings, the research team drafted a set of recommendations for the development of educational multimedia in the region, and built an interactive CD-ROM that applied these recommendations.

The first section of this paper discusses the importance of contextual learning in the South Pacific, as examined through interviews with staff and students, and a review of regional academic literature. In general, staff and students complained that as textbooks and other learning materials provided were developed for staff and students in other countries, they rarely used examples and metaphors from their own cultures. These findings are in line with established literature on education in the South Pacific. However, ramifications for educational multimedia development are still only beginning to be analysed in the USP region, so the second section illustrates several methods for the development of educational multimedia that can help provide this cultural context. In the absence of culturally relevant educational material, staff and students have come up with their own methods to create cultural context at USP. The second section analyses how these methods and lessons-learned can be applied to educational multimedia. Specifically, *decentralised* methods that enable students and teachers to customise educational multimedia themselves, and *dialogic* methods that provide local context through conversation-like interfaces, are demonstrated. These educational tools include a virtual peer, wiki, self-test, digital scrapbook, and three-tier file structure.

Although all of these methods were developed for students from cultures in the South Pacific, their flexible nature means that they can be useful in many other parts of the world. The underlying principle of providing easily adapted multimedia for use with diverse cultures and languages remains valid in a variety of cultures and situations.

Method

Participants

The research team collected data through interviews, questionnaires and usability tests with over 200 staff and students at USP. Since the research team was unable to visit all twelve countries served by USP, countries visited were selected to provide an even sample geographically and technologically. One Distance and Flexible Learning (DFL) centre was visited from each major geographic region in the South Pacific (Micronesia, Melanesia, and Polynesia) as well as one less developed and one more developed DFL centre. As such, DFL centres visited included those in Nauru, Samoa, the Solomon Islands, Kiribati, the Marshall Islands and Fiji. Interviews were conducted via telephone and email with staff and students from the remaining six countries served by the University of the South Pacific: Cooks Islands, Niue, Tokelau, Tonga, Tuvalu and Vanuatu. It is important to note that as questionnaires, usability tests, and interviews were conducted at the DFL centres, the sample did not include more isolated students who were unable to visit the DFL centres during the study.

Procedure

Interviews

153 interviews were completed during the course of the project. 130 of the interviews were with staff and students at the University of the South Pacific, and 23 were with members of external organizations in the South Pacific. These included ICT/Multimedia organizations such as Telecom Services Kiribati Limited (TSKL Kiribati), Datec, Internet Fiji, Aptech and Connect; development organizations such as the United Nations Development Programme (UNDP), the Forum Secretariat, and Peace Corps; government departments such as the Fiji Broadcasting Commission, the Fiji Ministry of Education, and the Nauru Ministry of Education; and educational institutions such as Central Queensland University, Nauru College, and the College of the Marshall Islands. The interviews focused on preferred approaches to learning and technology. The major themes covered included communication between staff and students, language preferences and issues, local metaphors in teaching, active learning, group/peer learning, computer access/usage, and centre access/usage. The individual interviews were supplemented by focus groups with academic staff. Notes and transcripts of the interviews are available online at the project website: http://nm.grographics.com, and links to notes for the interviews referenced in this paper are listed individually in appendix 1.

Questionnaires

The interviews were augmented with (and often jumpstarted by) three questionnaires. 196 focused on language preference, 196 focused on preference for the display of information, and 154 focused on layout preference for web-page navigation.

Usability tests

28 students conducted usability tests on sample educational software. The goal of these tests was to see how students work with educational multimedia, looking for trends in approach to the interface, common problems encountered, and methods used to solve these problems.

Results and Discussion

The importance of cultural context to staff and students in the South Pacific

Cultural context is an incredibly important aspect of learning in the South Pacific (Pagram et al., 2000; Taufe'ulungaki, 2003; Thaman, 1992, 2003a; Va'a, 1997). Traditional educational hierarchies in most member-countries of USP require that learning be grounded in the needs and context of indigenous culture before the learner is considered to have attained a high degree of knowledge (Ene, 2003; Lima, 2003; Mokoroa, 2003; Nabobo, 2003; Teaero, 2003; Thaman, 2003a).

On a purely practical level, students perform better when concepts are explained in terms of their personal experience (Okamura & Higa, 2000; Taufe'ulungaki, 2000). However, much of the educational material at USP makes use of examples and metaphors from Europe, North America or Australia (Henderson, 1993, 1996 in McLoughlin & Oliver, 2000; Thaman, 2000a).

Thus, the task of using local examples in many cases falls to the teacher. For example, Konai Thaman (2000b) attributes the high pass rate of her Educational Theories and Ideas course to the highly contextualised nature of the teaching and learning, as she has adapted the curriculum to reflect Indigenous educational ideas such as those of Kiribati, Tonga and Fiji.

During this study's interviews, a tutor in the Solomon Islands' DFL centre spoke of his students' difficulties with Australian textbooks filled with Australian examples, and offered the advice, "try to use a local example" (appendix 1:NmSolomons). The program assistant at the same centre echoed these sentiments,

> "It would be good to go through the courses to see where a regional example can be used, for each course, and truly go outside when we cannot find a regional example." (appendix 1:NmSolomons)

He went on to explain that even regional examples can sometimes be isolating:

> "Some of the course writers only use examples from the countries they know. If you look at sourcebooks, most use examples from Fiji and Samoa." (appendix 1:NmSolomons)

Staff at the Nauru centre also expressed the need for truly local examples:

> "The exam paper had to do with Kava [a drink popular in much of Polynesia and Melanesia]. It was like double-dutch to us." (appendix 1:NmNauru)

> "Most of the examples are very Fijian. We don't have veggy markets. We don't have military management. I have to pick something we can identify with." (appendix 1:NmNauru)

In the Solomon Islands, the chemistry tutor uses the local practice of chewing betelnut to teach about acids, bases and the chemical reactions of calcium oxide, lime and water (appendix 1:NmSolomons). In Kiribati, a computer science tutor uses the main atoll's one road to illustrate the concept of bit-rate and bandwidth: "here we have one lane, but get them to imagine we have several." (appendix 1:NmKiribati).

Lecturers also use local metaphors for more general tasks, such as course management. A lecturer at the USP Laucala Bay campus helps students see the inter-relatedness of the individual components of the larger course as a whole by describing the individual sections of the course as the strands of the *Sasa* broom, bound together to form a whole. She solidifies the idea that the components are all important to the whole with the aphorism "when you are a coconut, every part is useful." (appendix 1:NmSporeBrainstorm)

She also calls on the region's culture of story telling, illustrating different parts of the course with symbolic imagery:

> "On day one of the course the lecturer tells the story of the whole course, with pictures… and we are always going back to the map-story/conceptual map… relating it to a symbol"
> A lecturer at USP Laucala bay Campus
> (appendix 1:NmSporeBrainstorm)

During the interviews, students also spoke of the importance of cultural references. A management student at the Nauru DFL centre said that the course materials generally made sense, but that local tutors usually had to change the examples "on the fly" to make them applicable to the local situation. (appendix 1: NmNauru). Likewise, in discussing the importance of traditional education within institutional educational systems, a student at the Kiribati centre commented, "learning has been since our forefathers; it's only the system that has changed… most of our learning is related back to our culture." (appendix 1: NmKiribati) When a Samoan student studying

Agriculture was asked what he most wanted from educational multimedia, he responded “regional info, Pacific info.” (appendix 1:NmSamoa)

As a USP student noted in an earlier study,

> “I try to relate it [assigned reading at USP] to my background because most of the work is not on the Pacific”
> (Landbeck and Mugler, 1994, p. 29)

In summary, staff and students throughout USP’s 12 member-nations see a need for more local metaphors in their coursework, and often have to provide this cultural context themselves. Although this need has already been well documented in the regional literature already discussed, analysis of the role of educational multimedia in providing cultural context is still in relative infancy in the region. As such, the following section explores how educational multimedia developers specifically can provide opportunities for this context, illustrated with prototype products developed during the project.

Providing cultural context with educational multimedia

It is helpful to consider two methods for providing cultural context when developing educational multimedia: *decentralised* and *dialogic* contextualisation.

Decentralised contextualisation

Due to the large number of countries and distinct cultures that educational multimedia must serve at USP, providing truly local illustrations for every concept would be incredibly difficult to achieve. Educational multimedia developers can, however, give each country its turn, and anchor the regional examples to the student’s own background by giving the student a chance to provide input. Decentralised contextualisation refers to designing educational multimedia so that teachers and students can provide cultural context themselves, rather than relying exclusively on the multimedia developer.

Dialogic contextualisation

Dialogic contextualisation refers to framing educational multimedia interactions as conversations or personified interactions that provide cultural context. In Australia, “dialogic” interactive approaches that mimic conversation have helped motivate indigenous learners by linking their learning to their own community interests and needs (Ryan, 1992 & McCarthy et al, 1991 in McCloughlin & Oliver, 1999). Thaman (2000b) focuses her student’s studies of educational theories and ideas on the people associated with them because she has “found Pacific island students to be more people-oriented compared to other students.” In general, much of the literature on education in the South Pacific concludes that learners in the South Pacific are generally people-focused (Landbeck and Mugler, 1999 in Thaman, 2000a; Mokoroa, 2003; Pagram et. al, 2000).

Discussion Boards and Wikis

Discussion boards and “Wikis,” collaborative web sites that can be edited by any viewer, provide a decentralised method for contextualisation, making almost all of the content-development the user’s responsibility. The term “Wiki” is derived from the Hawaiian “Wiki-Wiki ,” meaning “quick” (Cunnigham, 2003). As such, a Wiki is meant to be a quick and easy way for non-technical users to create websites together.

Like the electronic discussion board, the Wiki enables staff and students to ask questions and give feedback when they are physically isolated from fellow students and lecturers. A key difference is that while in a discussion board users add comments progressively, in a Wiki users can edit each other’s content. This allows students and teachers to hone content into a single, collaborative website, facilitating a more structured result than discussion boards. It is an approach more in line with consensus than debate, closer to traditionally Pacific approaches to decision-making (Taufe’ulungaki, 2003; Teaero, 2003). As part of the project, the research team created an open “USPWiki” (figure 1) for testing and feedback, which can be viewed and edited at http://www.uspwiki.grographics.com.

An added benefit of these electronic means of peer learning is that they provide a perceived cushion of “e-anonymity” in social situations. Many students unwilling to ask questions of their lecturers in person, video conference or audio conference feel at ease emailing questions or using electronic discussion boards. (Appendix 1:NmMarshalls; Hunter, 2003) As a Math/Education student at the Kiribati centre put it, "for us it is better to email because it is not face to face" (appendix 1:NmKiribati). Of course, this does not advocate the use of technology as a way of avoiding interpersonal contact, but suggests that technology be developed that releases social unease rather than exaggerate it. This is particularly relevant in cultures where young people do not generally question authority figures (Nabobo, 2003; Reeves & Reeves, 1997 in McLoughlin & Oliver, 2000; Taufe'ulungaki, 2000; Teaero, 2003).

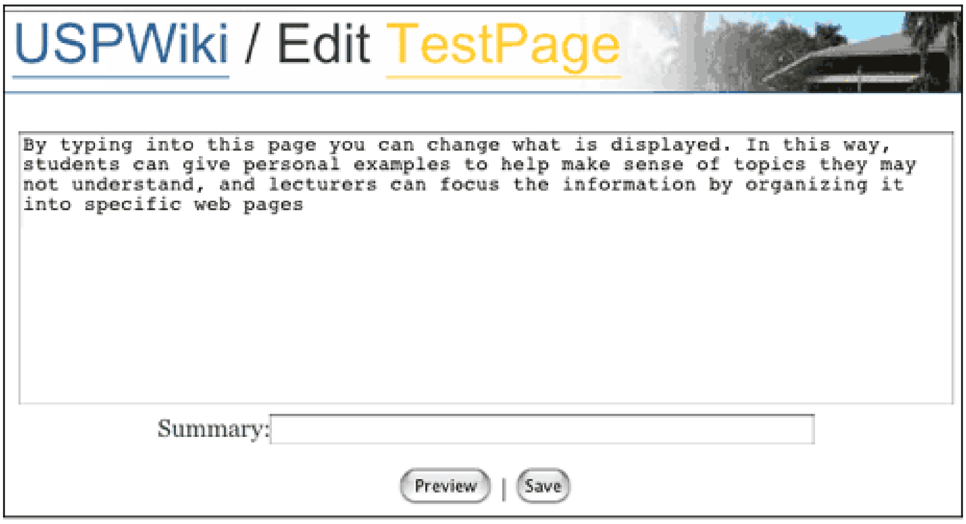

Figure 1: A page for editing the "USPWiki"

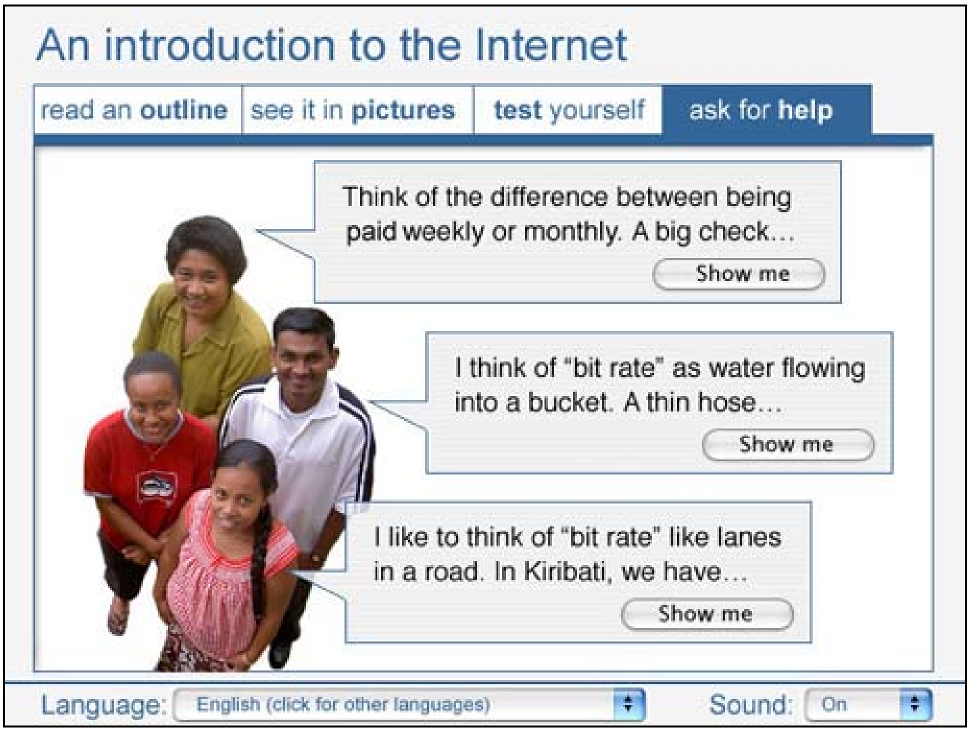

Figure 2: Virtual peers describe concepts in local terms

Limitations of Wiki and discussion boards

As many students in the South Pacific have little or no access to the internet (Frank, 2002; Landbeck and Mugler, 2000; Primo, 2001; Tuimaleali'ifano, 1999), it is important that educational technology developers also consider solutions not reliant on the Internet. Additionally, in order to mimic the role of modeling in Education in the South Pacific (Jordon et al, 1981 in Taufe'ulungaki, 2000; Thaman 1999; Va'a, 1997) the unstructured, unscaffolded aspects of the Wiki would need to be modified for use at USP. Moreover, Wiki, discussion board, and email are primarily text-based communications, which can alienate some students (Okamura and Higa, 2000). Multimedia has the potential for much more than text-based communication of ideas. As a DFL staff member at the Laucala Bay Campus pointed out,

> "Computer alleviates the 'loneliness of books' because it is interactive, like a person, has images and sounds, helps communicate with people"
> (Appendix 1:NmFiji).

Virtual Peer

A "virtual-peer" provides cultural context in a less text-intensive and internet-reliant way than email, Wiki, or discussion boards. By combining decentralized and dialogic contextualization methods, the "virtual-peer" allows the student to be engaged in conversation with fellow students from different parts of the South Pacific. Each student discusses the lesson in terms from his or her own country, illustrating his or her examples with animations, illustrations or audio clips (figure 2).

Decentralised aspects are utilized when the student is asked to discuss examples from his or her own culture, as in Figure 3. By saving the student's own examples on the computer, the software's library of contextualised learning metaphors can be built in a decentralised and personalised manner.

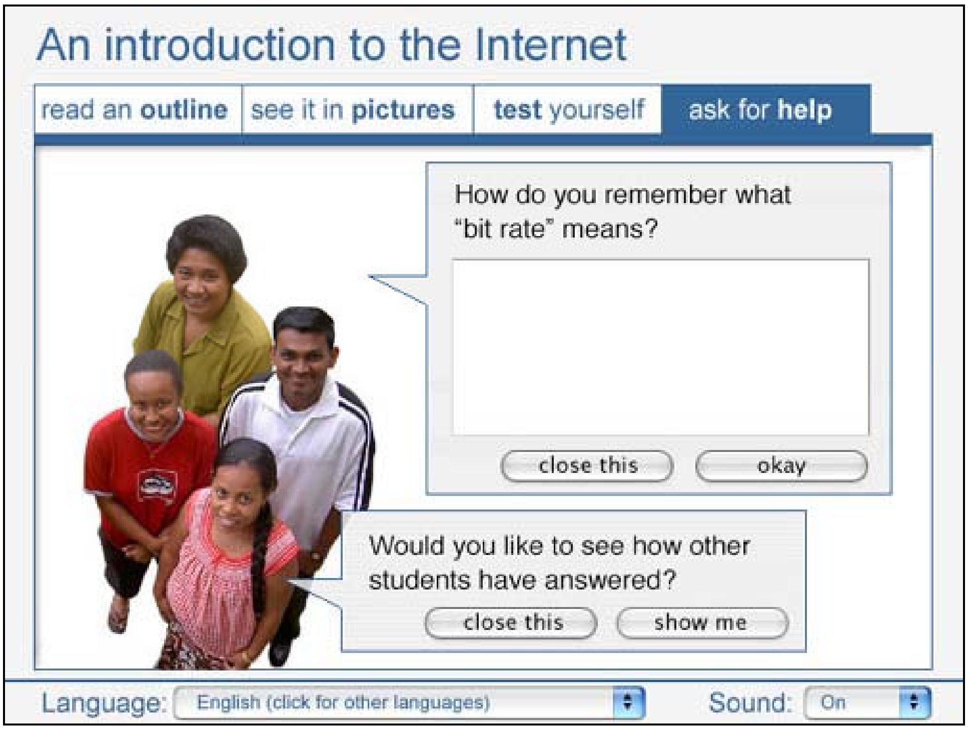

Figure 3: Students are asked to make their own metaphors

The digital scrapbook

When staff and students spoke of the aspects of collaborative learning they appreciated, the opportunity to share ideas came up frequently. A common thread through these conversations was the chance to translate what they were learning to their own situations and language, or as Mel (2001, p. 66) puts it, "local participation in making and realising the world." During the Solomon Island DFL Centre visit, Jerry Pakivai, a computer teacher, came upon an idea that can enable students to actively alter their learning materials to make them more applicable to their local context and learning needs: the digital scrapbook (appendix 1:NmSolomons). A digital scrapbook (figure 4) would allow students to copy portions of text, images and video, add their own information or summaries, trade their creations with other students and save them for individual study. By mixing a degree of constructive learning with passive materials, the electronic scrapbook caters to different types of students. Making the scrapbook printable enables it to be used at the student's home or when the electricity (often inevitably) goes out. While making educational materials printable may seem obvious, the dynamic and interactive nature of much multimedia can often make it difficult to print, so extra attention must be given to maintain sensible static versions alongside animated and dynamic media.

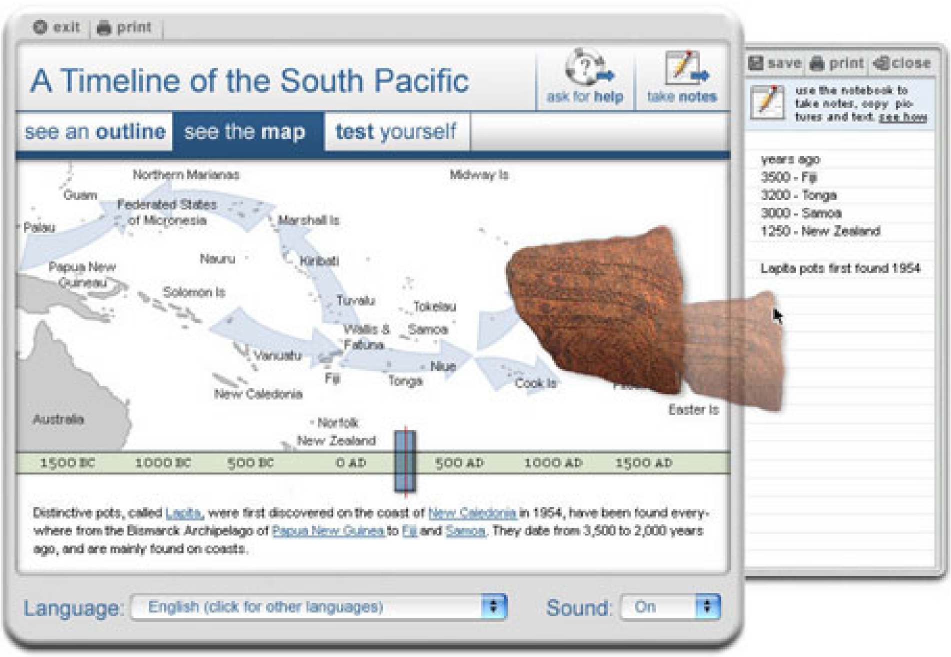

Figure 4: Digital scrapbook integrated into an educational multimedia program

A three-tier "Mothership" approach to file structure (figure 5), in which supporting files (text, images, video, audio) are separated from the core multimedia software, extends the digital scrapbook idea further by allowing the student's assembly to go on outside of the educational multimedia program.

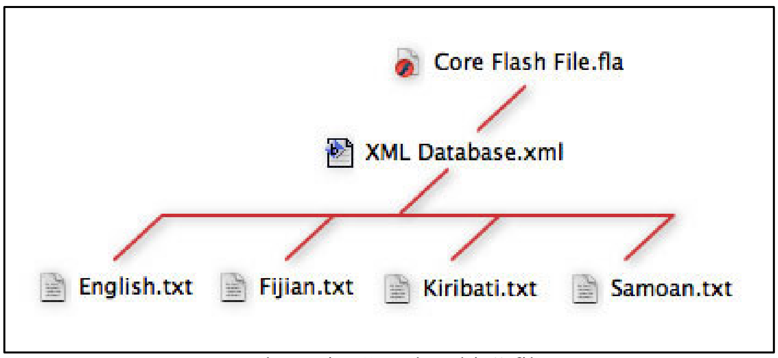

Figure 5: a three-tier "mothership" file structure

If every image, video, text and audio file is saved separately, students can view and reassemble many media assets without ever opening the educational multimedia program itself. Direct access to the individual components of a multimedia project is useful for students with older computers incapable of running high-end multimedia, or who prefer to use the operating system's built-in file navigation methods (opening documents in folders, etc.). Providing the supporting media separate from the educational multimedia has the additional benefit of encouraging re-use in other projects. For instance, course book creators could use the text portions in their print-based materials, tutors could use the images for their in-class presentations, and local radio stations could broadcast the audio files, all without ever opening the multimedia application itself.

Test yourself

Interactive quizzes can also provide cultural context if they are conceived more as a dialogue between student and peer than as an assessment method. In figure 6, the questions are worded such that the correct response can usually be derived from the question itself. In this way, the "test yourself" option is designed to strengthen conceptual links, helping students anchor what they are learning to something they already know or can intuitively understand. When a student responds incorrectly, the peer offers a hint and encourages the student to try again. In this way, the "test" mimics interpersonal dialogue, and encourages learning through trial and error. The "test yourself" is really a vehicle to give examination-driven students something to hold onto, providing cultural context by explaining the proper solution in terms of the students' own culture. Although the form (a test with hints) is familiar, the content's and goals differ from typical interactive quizzes, in that they are not assessment methods, but self-standing teaching tools that link coursework with stories from the student's background.

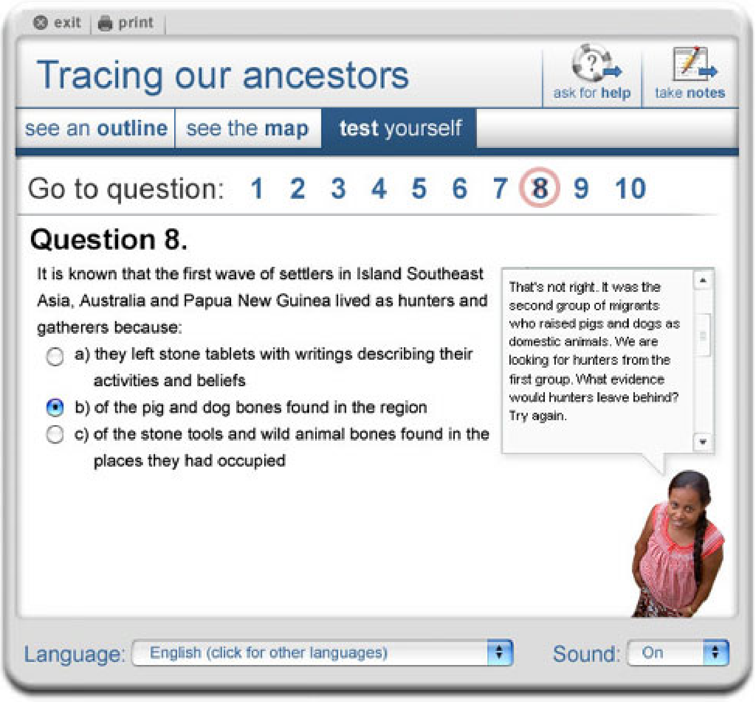

Figure 6: 'Test yourself'

Conclusion

The University of the South Pacific serves many cultures through its distance-learning program. Although staff and students at USP indicated a need for learning material situated in their own cultures, much of the educational material being provided is homogenous, and uses predominantly "western" metaphors and contexts.

The need for cultural context in formal education is also well documented by existing regional research, yet educational technology in the region is still largely developed using "western" learning constructs, tools, metaphors and examples. Developing cultural context from foreign educational materials has been an important aspect of teaching and learning in the South Pacific, and this study has built on the accomplishments and ideas of teachers and students by applying them to educational multimedia. This project developed multimedia solutions that can provide regional context, introducing a level of customisation and empowerment to the individual student and teacher.

Methods that educational multimedia developers can use to provide this missing cultural context were divided into *decentralised* and *dialogic* contextualisation. An important concept that bridges these approaches is encouraging teachers and students to customise educational multimedia themselves. This can be achieved by creating conversation-like interfaces such as the Wiki, virtual peer and self-test that use the back and forth between students and teachers to create truly relevant material. Customisation can also be encouraged by building software in easily editable formats, incorporating digital scrapbooks or organising media in three-tier structures so that individual files can be viewed, edited and re-used in isolation from the complete multimedia application.

It is important to keep in mind that locally-developed and culturally-contextualised multimedia is new to the USP region. Although regional teaching methods have been in use for centuries, and although teachers in the region have had to customise foreign learning materials for decades, concerns over how these methods and goals apply to educational technology are still in their infancy. As such, while there is a broad body of research on regional teaching and learning methods and concerns, links to technology are newer and more tentative. In this study, technology recommendations were extrapolated from interviews, usability tests, questionnaires and literature. And while the recommendations were audited and tested by target staff and students, a true test of their efficiency within the educational institutions of the South Pacific would require studies that compared classes that used these methods in their educational technology to those that didn't.

Moreover, in institutions where the value of producing graduates who can efficiently fit into "western" careers and concepts of success is being questioned, the entire notion of a "test for efficiency" requires further consideration. "Does the pacific really need so many more teachers and 'government' men? Are we caught up in the myth of manpower planning because we have failed to examine the basic premises of a developmental philosophy?" (Wah, 1997, p. 74)

While discussing possible conflicts between "pacific" and "western" tools and constructs, it is important to consider such conflicts within the research project. Although most of the programmers, participants and designers in this project grew up in the USP region, the project head grew up in a culture quite different from that of the staff and students who are the focus of this project. The impact of cultural biases on "outsider research," and the misunderstandings and misrepresentations such biases often introduce have been widely documented in academic press (Smith, 1999; Thaman, 2003b). Although staff from the USP region audited all methods and conclusions, and findings were based predominantly on the perspectives of people from the region, these conclusions, as with all educational media, should not be applied without undergoing further reflection by people from the cultures for whom the tools are developed. It would also be immensely valuable for people from the cultures represented in this study to conduct research looking at the links between regional pedagogy and educational multimedia.

Developed by "western" tools and constructs, multimedia can have alienating and westernising influences on South Pacific cultures. Through careful development of educational media according to the needs and values of the regions in which it is being used, it can have an enriching rather than diluting effect on the diverse cultures throughout the region. However, due to the relative infancy of educational multimedia studies in the region, and as the deeper issue of determining what constitutes culturally appropriate educational technology are multifarious and largely unresolved, the research team shifted the emphasis of their recommendations from deciding what is culturally relevant to methods that enable teachers and students to make their educational multimedia more culturally relevant themselves. Rather than deciding which approaches are more "pacific" or "efficient," the research team's recommendations allow teachers and students to use educational multimedia to craft their own solutions.

Acknowledgements

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Appendix 1

Notes and quotes from the interviews referenced in this paper

Title	Web Address
NmFiji	http://www.grographics.com/wiki/index.php/NmFiji
NmKiribati	http://www.grographics.com/wiki/index.php/NmKiribati
NmMarshalls	http://www.grographics.com/wiki/index.php/NmMarshalls
NmNauru	http://www.grographics.com/wiki/index.php/NmNauru
NmSamoa	http://www.grographics.com/wiki/index.php/NmSamoa
NmSolomons	http://www.grographics.com/wiki/index.php/NmSolomons
NmSporeBrainstorm	http://www.grographics.com/wiki/index.php/NmSporeBrainstorm

Franklin, K. K., & Hart, J. K. (2006). Influence of Web-based Distance Education on the Academic Department Chair Role. *Educational Technology & Society*, 9 (1), 213-228.

Influence of Web-based Distance Education on the Academic Department Chair Role

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ABSTRACT
The purpose of this study was to examine academic department chair perceptions about the future influence of web-based distance education on departmental operations and their changing role as academic leader. Using a rating, modified-policy Delphi method, the researcher worked with 22 department chairs employed at public, urban universities in the United States to develop 76 factor statements about the opportunities, pressures, changing relationships, and role of the chair. In a three-step process, the chairs reduced the 76 factors into 29 predictive statements. Furthermore, the researcher merged the predictions into six themes covering topics such as the importance of external agencies to the successful implementation of web-based education and concerns about future funding. Based on the findings, the researcher argued that the most efficient strategies to promote web-based distance education are through the efforts of the department chair due to the closer proximity of the department to external markets.

Keywords
Distance education, Web-based instruction, Delphi Study, Higher Education, Department Chair

Introduction

There is little doubt that web-based distance education provides public universities and colleges with a variety of opportunities to enhance visibility, sustain growth, and improve access to higher education. These same opportunities, however, come with inherent pressures on the status quo and traditional methods of knowledge construction and dissemination. Contemporary universities struggle to find strategies to fully capitalize on the possibilities while minimizing the problems. In turn, these combined opportunities and pressures influence important internal and external relationships for the academy. Just as the introduction of printing with moveable type and the classroom blackboard revolutionized educational practice -- following close on the heels of the influence of radio, television, and film on knowledge presentation and exploration -- web-based distance education is the next technological wave to flood educational thought and transform the academy (Daniel, 2002; Vrasidas & Glass, 2002).

Web-based distance education does not stand apart in the rapidly changing educational environment at the turn of the millennium. It is simply the most visible and outward sign of major transitions in higher education (Eoyang, 2004) due to the “need to innovate” by education constituents (Westera, 2005, p. 28). Web-based education is a driving force in its own right as well as a key component of contemporary educational movements, including equity of access and lifelong learning (Anderson, 2001; Caret, 2001; Connell, 1995; Holland, 2001); workforce preparation and business-university connections (Bates, 1999; Caret; Turoff, 1997); student consumerism and commercialization of higher education (Callan & Finney, 1997; Oblinger, Barone, & Hawkins, 2001; Rowley, Lujan, & Dolence, 1998; Turoff, 1997); improved capabilities of educational technologies, the Internet, and telecommunications (Bates; Oblinger et. al); and student-centered learning (Lucas, 2000; Palloff & Pratt, 1999; Tait & Mandell, 1999).

Its symbiotic relationship with other educational movements draws web-based distance education into debates over how higher education is delivered, to whom it is delivered, when and where it is delivered, and the goal of delivery (Eastmond, 1998; Oblinger et al.; Van Dusen, 2000). Responding to the needs and expectations of society, public universities are challenged to transform higher education from a place-bound campus-based learning system to one that provides accessible, high-quality, and low-cost education (Rowley, et al., 1998). Because of their role as the voice of faculty and administrative link for the college dean (Gmelch & Miskin, 1995), academic department chairs operate in a pivotal position related to transforming the academy. The purpose of this paper, therefore, is to explore the perceptions of chairs employed at public, urban universities about their predictions for future implementation of web-based distance education.

The Urban University

The challenge of responding to the needs and expectations of society is of paramount importance to those higher education institutions that serve an urban or metropolitan area. These institutions, often located in the heart of a metropolis, attract a diverse student population that reside and work in the surrounding urban area. These students are typically older, more ethically diverse, and attend multiple institutions generally taking more than four years to graduate (Johnson & Bell, 1995; Lynton, 1995; Twigg; 2000). The characteristics of the metropolitan university student closely resemble those best served by web-based distance education (Emil, 2001).

Dziuban and Moskal (2001) declared that "the metropolitan university's emergence and technology's rapid growth are the definitive educational movements in the latter part of the 20th century" (p. 42). The public university began to be a significant presence in large urban centers in the 1950s and 1960s. By the 1980s and 1990s, these universities embraced a mission of service to the local community. Each metropolitan university typically has a student population of 10,000 to 20,000 and provides undergraduate and graduate programs in both traditional and nontraditional formats (Lynton, 1995).

Due to a mission of serving nontraditional students commuting from work and home to the classroom, metropolitan universities rely on web-based technologies. In the mid-1990s, Connell (1995) urged metropolitan universities to use the latest generation of technology to enhance their mission related to workforce preparation and make connections with the business community in the surrounding metropolitan area. By the early 21st century, urban and metropolitan universities took the lead, in many cases, in the development and use of innovative instructional technology methods to meet the needs of a diverse student population and to achieve the mission of the institution (Warner, 2001).

Role of the Department Chair

As universities attempt to develop web-based courses and programs to capture a share of the on-line market and to respond to societal demands, the academic department plays a vital role in connecting development with implementation. Obviously, the reality of web-based distance education resides in the desire of faculty to effectively use on-line delivery and the ability of the academic department to garner the resources to support faculty efforts. Because the academic department chair is the resource gatekeeper, the chair is influential in the success or failure of any new initiative within the department. Through his or her multiple responsibilities of influencing departmental policies, goals, and objectives, and evaluating faculty performance, the chair has the ability to guide faculty interest (Carroll & Wolverton, 2004). With that said, it is apparent that one critical voice in the web-based education discussion is that of the academic department chair.

The multi-faceted role of the department chair is well-documented in the literature. This academic leader serves as an important link between the administrative requirements of the university and the faculty values of academic departments (Gmelch & Miskin, 1995; Carroll & Wolverton, 2004). Increasingly, the chair functions as a front-line manager for the university acting as the primary spokesperson for department faculty, staff, and students by articulating their needs to the administration (Hecht et. al., 1999). Likewise, the academic chair channels information from senior administration to faculty implementing policies and programs related to the institutional mission. According to Gmelch & Miskin, the department chair is situated at the "heart of the tension" between the department and the institution (p. 113) placing the chair in a pivotal position related to any academic programmatic change, such as web-based education (Hecht, Higgerson, Gmelch, & Tucker, 1999). Because of this position, the perception of academic chairs about web-based distance education can serve as a valuable conceptual framework in understanding the future development of on-line courses and programs offered by public universities.

Significance of the Study

Because of the symbiotic link between web-based distance education, the mission of the public, urban university, and the importance of the academic department in the successful implementation of web-based education, this study adds worthy insight into those issues that bolster or hamper web-based instruction. Likewise, due to the vital relationship between the academic department and the urban university mission, the department chair resides at a critical point of policy implementation. As stated earlier, this position makes the perception of the department chair an important consideration in the development of future web-based education policies and procedures. Whereas this study is only an exploration of a phenomenon and, therefore, is not generalizable to a target population, it is an important start in research about web-based instruction and the department chair.

To date, extant literature does not examine evolving opportunities, pressures, and newly found institutional relationships due to web-based technology from the perspective of the academic chair. Nor does the literature explore the future role of the department chair as a result of web-based education. Furthermore, research has not explored those constructs as related to the operations of an urban university. This study aims to fill the research gap by combining all of these constructs into an in-depth examination of the issues that may influence the future of web-based education. The resulting theoretical framework from this study provides senior administrators with a model for encouraging academic department chair support in the use of web technology for instruction. Even for those urban institutions that practice centralized governance, the department chair or division head is still influential in helping faculty form opinions of web-based instruction, opinions that are connected to their willingness to offer courses via the web.

The Delphi Technique

The Delphi technique, first introduced during the 1950s, has been defined as "a method for systematic solicitation and collection of judgments on a particular topic through a set of carefully designed sequential questionnaires interspersed with summarized information and feedback of opinions derived from earlier responses" (Delbecq, Van de Ven, & Gustafson, 1975, pg. 10). The technique has matured into one of the core tools for futures forecasting focused on surveying the environment to determine likely issues which will impact an organization, community, or individual (Lang, 1994). The Delphi method was developed to answer questions about the future when uncertainty and complexity exists (Sweigert & Schabacker, 1974, Conhaim, 1999). Martino (1972) described the areas well suited to Delphi methods as those in which (a) there is no adequate historical information, (b) judgment about the impact of many converging factors is required, and (c) technological progress depends more on the decisions of others than it does on the technology.

The technique is not a single method, but rather a family of methods with many variations and modifications (Martino, 1972). Every Delphi study is a structured group communication process with the following essential characteristics: (a) sequential questionnaires, (b) controlled feedback, (c) reiteration, and (d) anonymity of respondents (Lang, 1994). Delphi studies are accomplished through a series of either written, e-mail, or online questionnaires completed by experts on the subject (Stewart, 2001). The nature of each round of questionnaire and analysis is dictated by the nature of the previous round (Moore, 1987). The series of questionnaires is interspersed with feedback derived from participant responses through the informed judgment of a monitor (Fazio, 1984). The sequence of questionnaires and feedback continues until consensus is approached or until sufficient information has been exchanged (Delbecq et al., 1975).

Linstone and Turoff (1975) described three types of Delphi methods distinguished by their intent: (a) classical Delphi functioning as a forum for establishing facts, (b) policy Delphi functioning as a forum for generating ideas, and (c) decision-making Delphi functioning as a forum for decision making. Objectives of a policy Delphi study are "to ensure that all possible options have been put on the table for consideration, to estimate impact and consequences of any particular option, and to examine and estimate the acceptability of any particular option" (Turoff, 1975, p. 87). Moore (1987) differentiated the policy Delphi method from the more traditional Delphi method in that policy Delphi begins with a set of ideas gleaned from external sources, such as a literature review, from which the researcher formulates the initial questionnaire. According to Martino (1972), the initial questionnaire has the advantage of starting the panel off with a common base and context.

Many variations of Delphi methods, called modified Delphi methods, have been developed and used (Stewart, 2001). Ranking-type Delphi, a modified Delphi method created by Delbecq et al. (1975), is characterized by a rank ordering of all options by panelists. Lang (1994) found a modified policy Delphi method using ratings to be appropriate for detecting and describing structural changes in an organization. A modified policy Delphi is especially well suited when striving for stability rather than consensus and when divergent opinions must be acknowledged and included in the findings (Eggers & Jones, 1998; Lang, 1994). For these reasons, a rating Delphi, a common variation of the ranking-type Delphi using ratings on a 5, 7, 9, or 11-point scale to indicate the importance of an issue, was used for this study.

Research Method

The researcher purposively selected panelists from urban universities with an expertise about (a) academic department leadership, (b) the characteristics of a public university, and (c) web-based education. Two sampling frames were used related to these three criteria. The first sampling frame selected was the institutional membership directory for the Coalition of Urban and Metropolitan Universities (Coalition of Metropolitan Universities retrieved March 23, 2002, http://www.metrouniversities.com /directory.htm). The second sampling frame was Petersons.com Distance Learning website which provides a complete list of all universities offering courses or degrees, or both, via web-based distance education (Petersons.com Distance Learning, retrieved March 26, 2002, http://www.petersons.com/distancelearning/. As of March 2002, there were 58 members of the Coalition with 37 of those members listed on Petersons.com. The final sample included four institutions located in the Midwest, two in the Pacific Northwest, two in the South, two in the South Central, three on the East Coast, and one in the Mountain region. Twenty-two department chairs volunteered to participate on the Delphi panel.

Demographic Survey

At the beginning of the Delphi process a demographic survey was e-mailed, to each volunteer. The purpose of the survey was to provide information about the panelists related to their experience as a department chair and with web-based distance education. Based on the findings of the demographic survey, the 22 panelists who volunteered for this Delphi study were individuals who had some level of experience with and knowledge about the use of technology in their professional lives and as an instructional tool in the classroom. For the most part, these individuals viewed themselves as leaders in web-based distance education in their department and college. However, they were less likely to channel that expertise into committee service for their college, university, or state. A near majority of the panelists represented departments that used web-based instructional technology for undergraduate as well as graduate students. Likewise, a clear majority worked with an academic department that had the potential to tap into an income-producing market due to online courses and degree programs. Finally, the majority of the panelists indicated that their institution relied on individual faculty and academic departments for the creation and implementation of web-based courses and programs.

First Phase Questionnaire (FPQ)

Once the 22 panelists returned a completed demographic survey, the researcher sent an e-mail message to each panelist with an embedded hyperlink for the first questionnaire in the Delphi process. As prescribed by the modified policy Delphi procedure, the researcher prepared the FPQ using extant literature about web-based distance education courses and programs. The questionnaire was divided into four sections: (a) opportunities for the academic department because of web-based distance education courses and programs, (b) pressures placed on the academic department because of web-based courses and programs, (c) relationship changes influenced by the opportunities and pressures of web-based distance education, and (d) the future role of the department chair due to these new opportunities, pressures, and relationship changes.

At the beginning of each section, instructions were provided requesting panelists to rate their perception of the importance of factor statements on a 5-point Likert Scale with '0' indicating 'no opinion', '1' indicating 'not important' and '5' indicating 'critically important'. For example, the instructions for the 'opportunities' section stated, "*Please rate your perception as a department chair of the IMPORTANCE of the following opportunities, in the context of web-based distance education*". Each of the remaining three sections had similar instructions. The 'opportunity' section included 24 factor statements to include the following examples:

- Access to higher education for underserved student population
- Access for students located in the metropolitan area

The 'pressures' section of the questionnaire included 22 factor statements with the 'relationship' section totaling 17 factor statements. The 'department chair role' section included 13 statements for a total of 76 factor statements in FPQ. In addition to rating the factor statements, panelists were given the opportunity to make comments related to each section. The comments were shared with panelists in the second round and were coded in search of new factor statements. Thirty-six comments were analyzed for inclusion in SPQ resulting in 26 new factor statements.

Second Phase Questionnaire (SPQ)

The purpose of the SPQ was to fully explore the divergent opinions of panelists about each of the factor statements in the four sections. The outcome of the SPQ was the development of the final questionnaire in the Delphi process that contained predictive statements related to operating an academic department with web-based distance education. Just as the purpose of the FPQ was to 'jump start' the conversation, the purpose of the SPQ was to provide some level of stability in the diverse opinions offered by panelists. The SPQ was developed after the analysis of the ratings and comments submitted for the FPQ. The second questionnaire retained the same format as FPQ with four sections and factor statements within each section. Once again, the panelists were requested to rate their perception of the importance of opportunities, pressures, relationships, and chair role as influenced by web-based distance education. However with the SPQ, the researcher customized the questionnaire specifically for each panelist. On the newly customized questionnaire, the researcher included a statistical table for each section with the factor statement number, the 25 to 75% interquartile range for each factor statement, and the answer provided by the panelist. With that information at hand, each panelist could quickly ascertain how their responses to the FPQ correlated with the responses of their peers.

The instructions for the SPQ requested that the panelists use the interquartile information and reconsider their original response. The new factor statements developed based on the qualitative data from the FPQ were presented to the panelists for the first time in the SPQ and did not have interquartile information. Therefore, the value of the SPQ was threefold, providing panelists with a: (a) second opportunity to rate their perceptions allowing sufficient time for critical and reflective thought, (b) context for their ratings based on the ratings of their peers, and (c) new set of factor statements to considered based on their comments from the FPQ. The ratings for the SPQ were used to determine what factors would be presented to panelists in the culminating questionnaire #3.

Two primary methods were used to determine which factors were highly important as compared with those that were controversial. To determine the most important factor statements, the researcher compared the mean score for all factors using a 'cut-off' mean of 3.7 on the 5-point scale. Therefore, those factor statements with a 3.7 mean or higher were of significant importance to the panelists to remain in questionnaire #3. To determine controversial factor statements, the researcher compared the standard deviation of factor statements with a mean factor rating of less than 3.8. This method exposed additional factor statements for which the ratings indicated a spread of opinion and, therefore, were controversial. Because of the controversial nature of these factor statements, they were included in questionnaire #3. Finally, the qualitative data collected in SPQ was categorized and used to fine tune questionnaire #3.

Predictive Statements Questionnaire (PSQ)

The PSQ was the culminating questionnaire for this Delphi study. The purpose was to synthesis the 'important' factor statements, the 'controversial factor statements, and qualitative comments from FPQ and SPQ to develop predictive statements. A total of 29 predictive statements were included in the PSQ. (See Table 1)

The format of the third questionnaire was similar to the first and second questionnaire, in that, panelists were given the new predictive statements grouped together by the four previous sections of (a) opportunities, (b) pressures (c) relationships, and (d) chair roles. For this third round, however, panelists were requested to rate their 'desirability' for each predictive statement on a 5-point Likert Scale with '1' representing 'highly desirable', "3" as 'neutral' and '5' representing 'highly undesirable'. Immediately following the desirability rating, panelists were instructed to rate the 'likelihood' of the predictive statement occurring using the same 5-point Likert Scale with '1' representing 'highly likely' and '5' representing 'highly unlikely'.

To determine a final 'desirability score' and 'likelihood score', the researcher assigned weights to the desirability and likelihood scales. For example, the researcher multiplied the total number of panelists that rated a predictive statement as 'highly desirable' with a weight of '2', the total of panelists that rated a statement as 'desirable' with a weight of '1', and so on until all of the ratings were converted into a final desirability score. The same procedure was used for the likelihood rating. The final step in the process was to label a predictive statement based on the overall desirability and likelihood score. All statements receiving a score greater than '23' were labeled as 'highly desirable' and 'highly likely', a score between '5 – 23' were labeled as 'desirable' and 'likely', and so on until all predictive statements were given a label.

Table 1. Predictive Statements

Predictive Opportunities (PO)

Academic departments housed in a public metropolitan university will use web-based distance education to:

1. Increase matriculation of non-traditional students. (D:HL)
2. Increase matriculation of rural students. (HD:L
3. Develop a regional and /or national niche by offering:
   a) Degrees in areas of critical workforce shortages (D:L)
   b) Specialized degrees and certifications not commonly available (D:L)
   c) Degree completion programs (D:L)
   d) Educational opportunities at business locations (D:L)
4. Enhance the quality of courses taught in the department by employing technological advances whether the courses are designated as 'wed-based' or 'web-enabled. (D:L)
5. Create a student-centered learning environment. (D:L)

Academic departments housed in a public metropolitan university will operate in an environment where:

1. State and federal funding received for for-credit distance education enrollment is comparable to funding for on-campus student enrollment. **(D:UL)**
2. There is no funding differential between web-based courses and on-campus courses resulting in a course scheduling process based on the needs and demands of students. **(D:L)**
3. State, system, and institution-wide initiatives fund web-based course development and implementation. **(D:N)**
4. State, system, and institution-wide initiatives support the development and maintenance of a telecommunications infrastructure supporting web-based higher education. **(HD:N)**

Predictive Pressures (PP)

Because of the use of web-based distance education, academic departments housed in a public metropolitan university will:

1. Rely on grants, contracts, or other sources of external funding to support the creation of web-based programs and/or the development of web-based courses. **(D:L)**
2. Support already established web-based degrees and courses without requiring external funding such as grants and contracts. **(D:N)**
3. Continue to offer web-based distance education courses to:
4. Keep the metropolitan university competitive and viable. **(D:L)**
5. Keep the department competitive and viable. **(D:L)**
6. Accept and adopt new concepts related to the evaluation of student performance and the effectiveness of web-based educational experiences. **(D:L)**
7. Develop new pedagogic and technical skills to effectively use web-based capabilities appropriately. **(HD:L)**
8. Adopt work release and financial incentives commensurate with the effort involved in the creation of web-based distance education courses and conversion of traditional courses resulting in increased participation by faculty. **(D:N)**
9. Offer a course structure where web-based distance education courses and degrees co-exist in appropriate balance with traditional on-campus courses and degrees without negatively affecting on-campus offerings. **(D:L)**

Note: The following abbreviations are applicable: HD = highly desirable; D=desirable; N=neutral; UD=undesirable; HUD=highly undesirable; HL=highly likely; L=likely; UL=unlikely; HUL=highly unlikely

Predictive Relationships (PR)

1. Web-based distance education will be instrumental in the development of greater ties with external stakeholders such as business/industry and government agencies in providing higher and continuing education. (D:L)
2. The development and implementation of web-based courses and degrees will be primarily the responsibility of the academic department with little support or coordination from the institution. (N:N)
3. Institutional strategic planning for web-based distance education will include the administration, faculty, and other appropriate support units. (HD:L)

4. Information technology and other support units will act as advisors, not controllers, to faculty developing and implementing web-based distance education courses and degrees. (D:L)
5. Administration will provide a robust infrastructure to support web-based distance education, to include:
   a. Telecommunications networking including fast Internet connections. **(HD:L)**
   b. Faculty development related to web-based course preparation. **(HD:L)**
   c. A centralized unit to prepare courses working with faculty input and content. **(D:L)**
   d. An information technology unit that is aware of and abides by the academic calendar and other academic needs in their operations. **(D:L)**
   e. A distance education component of the institution that handles marketing and coordination of web-based distance education. **(D:L)**
6. The administration of the institution will plan realistically for the costs and revenues of web-based distance education. **(D:N)**

Predictive Chair Role (PCR)

1. Chairs heading departments offering online degrees and/or a significant number of web-based distance education courses will take a more proactive leadership role in programmatic decision making within the department. (D:L)
2. The chair will be more involved at the college, institution, and/or state level in strategic planning for web-based distance education. (D:N)
3. The chair will act as a vital communication link and departmental advocate channeling faculty needs to the administration. (HD:L)
4. The chair will play an active role in creating an environment conducive to web-based distance education by mitigating internal departmental politics surrounding web-based education and supporting the morale of all faculty. (HD:L)
5. Departmental resources such as staff, money, and equipment will be judiciously allocated to support web-based distance education efforts at an appropriate level that reflects its role in the department strategic plan. (HD:L)
6. The chair will lead the department in ascertaining the external market for web-based distance education offerings and identifying sources of funding for distance education efforts. (D:L)
7. The culture and operations of the department developing web-based distance education will be based on shared governance of departmental faculty. (D:L)

Note: The following abbreviations are applicable: HD = highly desirable; D=desirable; N=neutral; UD=undesirable; HUD=highly undesirable; HL=highly likely; L=likely; UL=unlikely; HUL=highly unlikely

Limitations of the Delphi Method

Several potential weaknesses found at various phases of a Delphi study are commonly noted. Perhaps the most daunting is that certain questions, indeed key questions, are not asked because they do not seem important when the study is started. Simmonds (1977) acknowledged that missing the target in the early stages could either invalidate a study or cause significant hardship on everyone involved. This might occur if the monitor of a modified policy Delphi study either creates an initial list of statements that does not define the issues/questions well enough to provide panelists with an adequate starting point or if the monitor does not incorporate the issue statements from the panelists appropriately. Even when the correct questions are asked it is vital that panelists understand that question and its related statements. Panelists might answer inappropriately or be frustrated to the point of losing interest.

The monitor also exercises a critical role because they control the key elements of implementation and analysis of the study (Stewart & Shamdasani, 1990). Moore (1987) suggested that the monitor might be a limiting factor if bias distorts either the formulation of the questionnaire or the results in such a way as to affect the outcome of the study. Imposing a process that is too restrictive on the panelists diminishes their input (Moore). Abusing the privacy of the panelists diminishes the free flow of opinions and insights (Moore).
Lang (1994) suggested that if the process of reaching consensus suppresses extreme points of view important new information or new insights may be lost. A policy Delphi study that seeks to illuminate issues fails in its mission if the study methods lose the valuable viewpoints of the individual panelists as the study pursues consensus and conformity rather than idea generation. The monitor should take concrete steps to ensure the

compilation and consideration of outliers (Blow & Sprenkle, 2001). In addition, if the monitor does not permit exploration of disagreements, discouraged dissenters might drop, thereby creating an artificial consensus (Linstone & Turoff, 1975).

The Delphi method cannot fulfill phenomenological purposes, but is best used for pretest and exploratory research (Frey & Fontana, 1992). According to Moore (1987), Delphi is not an end in itself and should be used within a larger process or to lay the groundwork for further investigation. The validity and reliability of a Delphi study rests in the selection of the panel, the creation of the instruments for collecting responses, the care with which the researchers used the responses of the panelists to improve upon the instruments as suggested by the panelists, and the interpretation of the data.

In this study, the researcher developed the research method after reviewing extant literature on the criticisms of the Delphi method and designed a protocol sensitive to those issues. Each phase of the Delphi method included opportunities for open-ended questions to allow nonrestrictive discussion by participants. As outlined in the research method below, the researcher used a web-based program that protected the privacy of panelist's, only the researcher knew the identity of each panelist. Panel selection followed a strict protocol to ensure the selection of a representative sample. Finally, outliers were identified in the study, included in the questionnaire for each phase, and used to encourage continued debate through the comments section of the questionnaire.

The only criticism remaining that was valid as a limitation to this study was the use of initial key questions by the researcher. As noted, the researcher developed the first questionnaire based on a review of extant literature. Therefore, the limitation exists that the researcher may have inadvertently influenced the answers of panelist or the direction of thought. However, through the three phases of discussion and the practice of the researcher in encouraging debate and in-depth comments, participants in this study had, and took, the opportunity to add to the initial key questions.

Results

The majority of the predictive statements had scores representing a certain level of 'desirability'. This finding was congruent with the Delphi process keeping in mind that the purpose of Delphi is to reach some level of stability in opinions through continuous rounds of discussion about a given topic. Therefore, finding that most of the predictive statements were desirable to the panelists was not surprising. In fact the only statement that deviated from the desirability score was related to the role of academic departments supporting web-based distance education without support from the college or institution. This statement received a 'neutral' total score on both desirability and likelihood.

Opportunities

The predictive statements were written as a result of panelists' quantitative ratings of factor statements in the FPQ and SPQ as well as their qualitative comments. Therefore, these statements were a product of department chair perceptions about the influence of web-based distance education and the operation of the academic department. With this in mind, the themes embedded within the predictive statements are as telling as the desirability and likelihood scores. For example in the first five predictive opportunity statements, the theme for two statements revolved around enhancing opportunities for the department by improving access for students. A third theme related to developing a student-centered, as opposed to teacher-centered, learning environment within the department. All three of these 'student-oriented' opportunity statements received high desirability scores.

The remaining predictive opportunity statements centered on themes related to enhancing the (a) visibility of the department, (b) quality of courses, and (c) federal, state, system, and institution-wide involvement in web-based distance education. The majority of panelist desired support from stakeholders external to the academic department for web-based distance education with most remaining unoptimistic about those predictive statements coming to fruition.

Pressures

Unlike the common 'student' theme found within the predictive opportunity statements, the statements predicting future departmental pressures due to web-based distance education were more diverse. Of the seven pressure statements, two statements were polar opposites as related to funding web-based courses and programs. Both of these statements evolved from panelists' comments on the first two questionnaires and reflected the funding dichotomy experienced by these department chairs. On the one hand, the panelists desired a funding situation where the academic department could support web-based education without the need for attracting grant and contract dollars. However, the majority of panelists indicated that they were 'neutral' as to the likelihood of this possibility. On the other hand, panelists were lukewarm in their support for attracting outside grant and contract monies indicating, however, that this pressure on the department to become more 'grant-savvy' was closer to reality.

The panelists also recognized the likelihood that future academic departments housed in a public, urban university would continue to receive pressure to offer web-based courses and programs with the goal of achieving the mission of the university and ensuring that departments remain competitive. Additionally, these department chairs predicted that there would be ongoing pressure to design and implement assessment tools for the web-based learning environment. Related to that unique learning environment, these department chairs supported the predicted pressure of developing faculty incentive packages commensurate with the time investment required for developing courses and programs online. They also supported the pressure of providing a strategy to allow online and on-campus courses to co-exist. Interestingly, however, the panelists were neutral as to the likelihood of either of the latter two becoming a reality.

Finally, just as these department chairs predicted the opportunity of using web-based technologies to enhance the quality of courses offered, they predicted that their academic departments would receive continued pressure related to this opportunity. In fact of all seven predictive pressure statements, the statement related to the development of new pedagogic and technical skills to effectively use web-based technologies received the highest desirability and likelihood score.

Relationships

The predictive relationship statements addressed a host of themes ranging from the relationship between the academic department and (a) stakeholders external to the university, (b) the institution, and (c) the administrative unit responsible for providing technology support. Of the six relationship statements, one statement continued the theme threaded through the opportunity and pressures section of connecting the academic department to external constituencies because of web-based distance education. The panelists agreed on both the desirability and likelihood of connecting their departments with outside groups due to a common interest in the effectiveness of web-based courses and programs.

These panelists predicted that web-based distance education would influence the relationship between the academic department and the institution through the strategic planning process needed to plan and implement web-based education. They looked to the institution to develop and implement quality telecommunications networks, faculty development related to web-based education, and a centralized unit to manage the marketing of web-based courses and programs. So much so, in fact, that these department chairs were neutral both in their desire for and predicted likelihood of a relationship with the institution in which the academic department was solely responsible for the implementation of web-based courses and programs. They were lukewarm in their desire to have a centralized unit of the institution to prepare online courses even with faculty input on content. However, they did believe that this type of centralized unit was likely for the future. Whereas, they desired an institution that was realistic in determining the costs of and revenues for web-based distance education, they were neutral in their prediction of the likelihood that this relationship would actually develop.

The final relationship important to these department chairs was with the information technology support unit for the institution. They indicated a desire for and predicted the likelihood of an information technology unit that served as 'advisors' to, and not 'controllers' of, faculty developing and implementing web-based courses and programs. They also desired a relationship with the information technology unit that resulted in the sensitivity of the unit to the demands and needs of the academic department.

Chair Roles

The culminating section of the predictive statements was the influence of the opportunities, pressures, and relationships on the chair's role as predicted by these panelists. The seven predictive statements related to the future role of the department chair merged into three overarching themes. Those themes included the planning for web-based distance education, implementation of web-based courses and programs, and departmental governance of web-based education. These panelists highly desired a strategic departmental plan that judiciously allocated departmental resources toward web-based distance education based on the goals of the department. They supported the role of the department chair in ascertaining the external market for distance education courses and programs, and in identifying sources of funding from those markets. These department chairs, however, indicated a weaker desire with a neutral perception of likelihood for the chair taking a role in strategic planning for web-based education at the state, institution, or college level.

Related to the implementation of web-based distance education courses and programs, the panelists highly desired and deemed likely the future role of the chair in developing an environment conducive to effective web-based offerings and supporting the morale of faculty. Of equal desirability and with the likelihood of occurring, these panelists predicted a significant future role for department chairs as serving as a faculty advocate related to the unique needs of providing distance education courses. Likewise, the department chairs serving on this Delphi panel provided information that informed the development of two predictive statements related to the governance of web-based distance education courses and programs. First, they indicated a strong desire for the development of web-based courses and programs based on shared governance by departmental faculty. Second, they supported a more proactive role by the chair in making programmatic decisions related to online and on-campus courses for their department.

Theoretical Framework

The predictive statements included in this study were a culmination of a three-step questionnaire process. (See Table 1) Twenty-two department chairs representing a variety of disciplines in a variety of public, urban universities with some experience in web-based distance education shared their thoughts on the future of web-based education and the role of the department within that future. The panelists merged 76 factor statements about the opportunities, pressures, relationships, and the changing role of the department chair as related to web-based distance education into 29 predictive statements. The purpose of these statements was to predict the influence of web-based distance education on the future operations of the department.

To form a theoretical framework from the 29 predictive statements, the researcher merged the statements into six overarching themes explaining the phenomena of web-based distance education as academic departments learn to operate in that environment into the future. (See Table 2). Those themes included: (a) the relationship between the academic department and external agencies, (b) funding web-based courses, (c) ensuring the viability of the university and the academic department, (d) enhancing learning, (e) ensuring faculty development and compensation, and (f) developing a sound technology infrastructure. These themes, or theoretical constructs, explain the contemporary thinking of academic department chairs about web-based technology and, perhaps, influenced their willingness to support web-based instruction. Whereas, these constructs may not provide startlingly new revelations, they do offer researchers and senior administrators with a guide for future strategic planning from the perspective of the chair.

Theoretical Constructs

As noted in Table 2, the first theoretical construct – External Agencies -- blends predictive statements related to the importance of external agencies to a department chair in providing necessary support for web-based technology. Chairs want involvement at the state, system, and institution level in maintaining a sound telecommunication network and providing necessary funding to support that network. The chairs in this study predicted the need for valid strategic planning related to web-based education recognizing that their involvement in that planning would be an important future role for the chair. Improving relationships with business, industry, and government agencies was an important opportunity for academic departments due to web-based access.

The second construct, funding web-based education, explains the importance department chairs place on resource development for the support of web-based technologies. These department chairs debated the need for procuring grant dollars to fund technology or relying on already established support from the state, system, or institution. While all chairs participating in the study found either option desirable, they agreed that most urban institutions would place pressure on the academic department to procure grant funding. They also predicted that a new role for the department chair would revolve around their leadership in procuring that funding. Linked to funding, these chairs predicted increased pressure on institutions to plan realistically for the true costs and revenues associated with web-based offerings.

The viability of the university and department was the third theoretical construct and included the perception by department chairs of the value of web-based technology in helping the institution and department build a national or regional niche by offering specialized degrees in critical need areas. This construct pointed to the need for future chairs to take a leadership role in programmatic and curricula decision making to ensure that courses were offered on-line that was congruent to these needed degrees. In the fourth construct, department chairs predicted the ability of web-based instruction toward enhanced learning due to the matriculation of students not otherwise served by higher education, quality of web-based courses, and student-centered nature of web technology. Interestingly, however, these chairs did not develop a predictive statement as to their role related to enhance learning through web-based distance education. Perhaps, this role of ensuring quality learning is so embedded in the job of the department chair that these chairs did not believe it necessary to develop a predictive statement related to this theme. Or, these department chairs may view enhanced learning as a responsibility of faculty and therefore not within the discussion of predicting the future role of the department chair.

It comes as no surprise that academic department chairs developed predictive statements addressing the importance of faculty development and compensation for the success of web-based distance education. In this fifth construct, these chairs predicted the continued importance of providing work release and financial incentives for faculty willing to tackle web-based education. They underscored the need for faculty development related to course preparation for on-line courses and the possibility of a centralized unit on campus to help faculty prepare courses. Chairs participating in this study predicted a new role for future department chairs in creating an environment conducive to web-based instruction.

The final theme, technology infrastructure, includes predictive statements made by these department chairs as to the importance of providing a sound technology infrastructure to ensure the success of web-based courses. The participants in this study predicted the continued need for an information technology support unit that acted as advisors to faculty helping in course development and implementation, a unit that understands and abides by the needs of the academic department. Additionally, they predicted the need for a centralized unit that would manage the marketing component of distance education along with coordination of courses offered on the web.

Table 2. Theoretical Framework

Construct #1: External Agencies

1. There is no funding differential between web-based courses and on-campus courses resulting in a course scheduling process based on the needs and demands of students.
2. State, system, and institution-wide initiatives fund web-based course development and implementation.
3. State, system, and institution-wide initiatives support the development and maintenance of a telecommunications infrastructure supporting web-based higher education.
4. Web-based distance education will be instrumental in the development of greater ties with external stakeholders such as business/industry and government agencies in providing higher and continuing education.
5. Institutional strategic planning for web-based distance education will include the administration, faculty, and other appropriate support units.
6. The chair will be more involved at the college, institution, and/or state level in strategic planning for web-based distance education.

Construct #2: Funding Web-based Distance Education

1. State and federal funding received for for-credit distance education enrollment is comparable to funding for on-campus student enrollment.
2. Departments will rely on grants, contracts, or other sources of external funding to support the creation of web-based programs and/or the development of web-based courses.
3. Support already established for web-based degrees and courses without requiring external funding such as grants and contracts.
4. The administration of the institution will plan realistically for the costs and revenues of web-based distance education.
5. Departmental resources such as staff, money, and equipment will be judiciously allocated to support web-based distance education efforts at an appropriate level that reflects its role in the department strategic plan.
6. The chair will lead the department in ascertaining the external market for web-based distance education offerings and identifying sources of funding for distance education efforts.

Construct #3: Viability of the University and Department

1. Department will develop a regional and /or national niche by offering degrees in areas of critical workforce shortages; specialized degrees and certifications not commonly available; degree completion programs; and educational opportunities at business locations.
2. Department will continue to offer web-based distance education courses to keep the metropolitan university and department competitive and viable.
3. Chairs heading departments offering online degrees and/or a significant number of web-based distance education courses will take a more proactive leadership role in programmatic decision making within the department.

Construct #4: Enhance Learning

1. Web-based education will increase matriculation of non-traditional students and rural students.
2. Web-based education will enhance the quality of courses taught in the department by employing technological advances whether the courses are designated as 'wed-based' or 'web-enabled.
3. Web-based education will create a student-centered learning environment.
4. Departments will accept and adopt new concepts related to the evaluation of student performance and the effectiveness of web-based educational experiences.
5. Universities will offer a course structure where web-based distance education courses and degrees co-exist in appropriate balance with traditional on-campus courses and degrees without negatively affecting on-campus offerings.

Construct #5: Faculty Development and Compensation

1. Departments will develop new pedagogic and technical skills to effectively use web-based capabilities appropriately.
2. Departments will adopt work release and financial incentives commensurate with the effort involved in the creation of web-based distance education courses and conversion of traditional courses resulting in increased participation by faculty.
3. Administration will provide a robust infrastructure to support web-based distance education including faculty development related to web-based course preparation and a centralized unit to prepare courses working with faculty input and content.
4. The culture and operations of the department developing web-based distance education will be based on shared governance of departmental faculty.
5. The chair will act as a vital communication link and departmental advocate channeling faculty needs to the administration.
6. The chair will play an active role in creating an environment conducive to web-based distance education by mitigating internal departmental politics surrounding web-based education and supporting the morale of all faculty.
7.

Construct #6: Technology Infrastructure

1. Information technology and other support units will act as advisors, not controllers, to faculty developing and implementing web-based distance education courses and degrees.
2. Administration will provide a robust infrastructure to support web-based distance education including telecommunications networking including fast Internet connections.
3. Administration will design an information technology unit that is aware of and abides by the academic calendar and other academic needs in their operations.
4. Administration will provide a distance education unit that handles marketing and coordination of web-based distance education.

Use of Framework to Guide Strategic Planning

All six constructs can guide future planning and decision making for the successful implementation of web-based distance education. Keeping in mind that the value of the Delphi method resides in the brainstorming activity of a small group about a specific topic, the theoretical framework suggested above is not generalizable to a larger population of academic chairs. It is meant instead as a starting point in the discussion about the chair role in the implementation of web-based distance education. With that said, there is worth in using the framework to include chair perceptions in the strategic planning process for web-based education implementation.

In developing incentives for departmental participation, senior administrators should heed the value chairs place on developing viable relationships with external markets by offering specialized degrees. Designing strategies to help departments tap into those markets would certainly improve faculty willingness to participate in web-based instruction. Furthermore, administrators should be cognizant of and find strategies to address the desire by department chairs for support from the state, university system, and institution for distance education by working with these agencies to garner needed resources and communicating the availability of those resources to the department chair.

Likewise, these department chairs recognized their responsibility related to helping their department identify sources of funding and judiciously allocating resources to support web-based education within the departmental strategic plan. Because these department chairs understand the importance of their role in seeking and distributing funds, university administrators have a strong ally already in place in the implementation of web-based distance education. To fully utilize that ally, administrators must design strategies that support efforts by department chairs in the pursuit of their funding goal. Because the academic department is closer to the external market for each discipline, the most efficient investment of resources for web-based education should focus on the strategies of the department.

Evident in the findings from this study, department chairs recognize the potential of web-based education in promoting access to and quality of learning. Once again, senior administrators are encouraged to tap into this support for web-based education by communicating the possibilities of enhanced learning via the web and helping departments find pedagogic strategies for using web technologies. However, as these academic chairs predicted, all of the above strategies become moot if the institution does not provide reliable technology infrastructures. Senior staff must remain mindful of the importance of the infrastructure to academic departments and develop strategies to ensure quality and dependability.

Conclusion

The findings of this study paint a dichotomous view of web-based distance education with the opportunities for success on the one hand and the predications about lack of support outside of the department on the other. It is reasonable to assume that the academic department chairs in this study serve institutions that provide varying degrees of support for web-based distance education. Some senior administrators may believe that they offer adequate support to departments and faculty given constrained resources. However, as is evidenced in this Delphi study these department chairs do not share that perception. Web-based distance education is the next technological wave to flood the academy with department chairs serving as the front-line academic leaders. Therefore, it is imperative that administrators heed the perceptions of these individuals. Quite simply, the academic department chair can make or break an institution's desire to embrace web-based distance education.

According to Myers, Bennett, Brown, and Henderson (2004), "extant research on the [advantages and disadvantage] of educational technology and online learning environments is mixed" (p. 2), therefore emphasizing the need of academic leadership to provide direction and guidance for faculty on the use of web-based distance education. As an instructional innovation, web-based distance education demands the attention of the department chair. Ensminger, Surry, Porter, & Wright (2004) found four conditions necessary for successful implementation of an innovation. The four conditions were managed change, performance efficacy, external rewards, and resources. The researchers developed a survey instrument with 32 statements based on a theoretical framework postulated by Donald Ely (1990, 1999). The survey was administered on-line using a sampling frame of instructional designers. Instructional designers (N = 179) employed in a variety of environments to include K-12, higher education, business, military, government, and designers that were self-employed responded to the survey. Using factor analysis, the data merged into the four conditions mentioned explaining approximately 73% of the total variance.

The researchers defined 'managed change' as the desire of organizational members for leadership providing clear direction and guidance during the innovation and implementation stage (p. 68). 'Performance efficacy' referred to the need of members to perceive that they currently have the skills needed to accomplish implementation or that they can quickly obtain those skills. 'External rewards' simply referred to the desire by organizational members for compensation or incentives related to the work of implementing an innovation. Finally, 'resources' was defined by researchers as the need by organizational members to perceive sufficient resources to maintain quality technology before the implementation phase begins (p. 69).

Managed change is congruent with the argument offered in this study that the role of the academic department chair is crucial to the successful implementation of any innovation to include web-based distance education. This leadership role makes the perceptions of academic department chairs important to the discussion of successful web-based programs and courses. The remaining three factors are represented in the resulting theoretical framework from this study by two of the six theoretical constructs -- faculty development and compensation and funding web-based education. It seems reasonable to deduce that the academic department chairs in this study were very cognizant of the two areas of concern by faculty related to innovation implementation. Whereas a more in-depth comparison of the findings from the two studies would be invalid due to differences in research design, it is interesting to note that 'faculty development and compensation' and 'funding web-based education' may come from department chair interactions with faculty and listening to their concerns about web-based education. On the other hand, building relationships with external agencies, ensuring university and department viability, enhancing student learning, and developing a sound technology infrastructure are, perhaps, perceptions that have evolved over time due to the *process* of implementing an innovation and the unique experiences of the chair as a front-line manager.

In the final link between theory and practice, it is recommended that university administrators use the above themes as a framework for developing strategies to support the academic department chair in implementing successful web-based programs. Understanding the value these chairs place on using web-based technologies to identify their niche in the external market, enhancing student learning, and ensuring the viability of the department provides administrators with a tool for encouraging departmental participation in web-based learning. Recognizing that department chairs place an emphasis on faculty development and compensation as well as involvement in decision-making about web-based offerings should inform administrator practice in developing effective web-based programs. Focusing on the concerns of chairs related to funding web-based courses in equity with traditional courses and ensuring a sound technology infrastructure to support faculty and student work affords administrators the opportunity to attend to those concerns that are the most important to the department chair.

Recommendations for Future Research

The value of the Delphi approach is to provide a theoretical framework for future exploration based on the thoughts of an expert panel in the research area. To that end, recommendations for future research revolve around the need to take this theoretical framework and design future qualitative studies that explore in-depth the predictive statements in this study or quantitative studies that confirm the framework. Additionally, other studies are needed with a diverse sample of universities. Because this study focused on department chairs within urban universities, the data are limited to those types of institutions. Further research is needed on department chair perceptions for research universities and community colleges.

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Testing the pedagogical expressiveness of IMS LD

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ABSTRACT

The IMS Learning Design specification (LD) was introduced as an answer to the shortcomings of existing learning technology specifications. The main difference with existing specifications is that LD is an abstract, conceptual model that is able to express various pedagogical approaches whereby content can be adapted to personal needs and assessments can be integrated. In this article we evaluate the pedagogical expressiveness of LD by taking a set of 16 lesson plans and expressing them in LD. We use three different methods to identify difficulties in expressing the lesson plans in LD. Difficulties identified included circulating a document within a group, giving instructions prior to the start of an activity, random assignment of a group member to a role, group formation at runtime, creation of an inventory to map pre-knowledge, learning objectives and learning achievements, and a way to communicate information on how to deliver a lesson to a teacher. We did not find situations that were impossible to express with LD. The difficulties found are elaborated and suggestions to handle them are given. The methods used are compared and suggestions are given for further research.

Keywords

IMS Learning Design, Open specifications, lesson plan, educational modelling language

Introduction

The use of technology in education has become common in recent years. Delivery mechanisms used in education are increasingly based on technology. Learning technology specifications and standards are designed to facilitate the creation and use of learning content and support material in such a way that it can be exchanged and reused by others. Outside the domain of education there are several examples which illustrate the advantages of standardisation. For example, DVD is an industry standard for delivering movies to consumers; the MP3 format is a de facto standard used to exchange music; and similarly PDF is a standard for exchanging documents. The benefits of standards for users are evident; consumers can be assured that if they purchase a product outside their domestic market it will still be unusable. However, the educational field has not yet reached this stage of standards adoption. There are a number of open specifications that overlap or only partially cover educational needs and likewise propriety systems that impede the exchange of educational material with other systems than their own.

Educational institutes need to make large investments to set up infrastructure to support the requirements of life long learning, globalisation, and a need to continuously access knowledge. Many education and training institutes are exploring the possibilities of the use of internet-based learning management systems (LMS) for the delivery of courses and curricula. One of the functions of an LMS is facilitating the administrative process that is needed to enrol learners, to assign them to courses and to deal with authentication and authorization issues such as user accounts, passwords or assigning rights to different user roles. Learning technology specifications can be used to describe the educational content delivered through the LMS or to facilitate exchange of learning materials between institutions.

For a long time, the focus of learning technology specifications was on developing specifications for learning objects. A learning object is defined by the IEEE LTSC (2000) as any entity, digital or non-digital, that can be used, reused or referenced to during technology-supported learning. Specifications for learning objects have primarily been designed to ensure interoperability, focusing on technology issues and reuse. The instructional value of learning objects is rarely discussed.

Most of the open e-learning specifications released for course development and course delivery up to now are limited to a restrictive set of supported pedagogies (Rawlings et al., 2002). If we look at the full spectrum of course development and delivery, most specifications focus on the description of learning objects and meta-data and on sequencing learning objects. The Sharable Content Object Reference Model (SCORM), which is widely used for delivering educational material (Olivier & Liber, 2003) is based on the assumption that learning content can be decomposed into discrete, context independent entities. The result of this narrow focus is that learning is limited to the consumption of content. Teaching is then limited to the art of selecting the right content and putting it in a structured, sequenced way, and of tracking the learner's progress and assessing the acquired knowledge. Meta-data specifications such as Dublin Core and IMS LOM are used to describe elements that are then used to assemble learning objects into 'courses' but they are too limited to describe the interaction between the elements.

There are also other initiatives to describe education, such as the semantic web. The challenge the semantic web seeks to meet is to provide a language that expresses both data and rules for reasoning about data, and that allows rules from any existing knowledge-representation system to be exported to the web. An important question for the educational semantic web is how to represent a course in a formal, semantic way so that it can be interpreted and manipulated by computers as well as by humans. Although our approach may not be considered an offspring of the semantic web approach, it certainly is in line with its tenets. Below, we will present a semantic model that can be described with a formal modelling language, such as UML (Booch et al., 1999; OMG-UML, 2003). The UML class diagrams can be translated to RDF-Schema and/or OWL Web Ontology Language, depending on the richness of the model (Chang, 1998; Melnik, 2000).

To overcome the limitations of existing learning technology specifications and standards, the Open University of the Netherlands developed a specification named Educational Modelling Language (EML) (EML, 2000; Hermans, Manderveld, & Vogten, 2004; Koper & Manderveld, 2004). EML provides a pedagogical framework of different types of learning objects, expressing relationships between the typed learning objects and defining a structure for the content and behaviour of the different learning objects. Based on EML, the IMS Learning Design specification (LD) was developed and released in 2003. Unlike SCORM, LD is able to describe units of learning based on different theories and models of learning and instruction together with the learning objects used, and can be adjusted to personal needs. As such, LD has the potential to describe a far greater array of learning processes than SCORM (see also Lukasiak et. al., 2005).

Current meta-data initiatives are focused at the learning object level. There are no meta-data schemas that describe how learning objects are aggregated and used in a learning environment (Lukasiak et. al., 2005). LD could be interpreted as a form of meta-data specifically for the learning domain. In this context, it would then be used to describe the objects and events in the teaching-learning process. In comparison with other meta-data specifications, it has the added benefit of being able to be read by a machine and displayed to learners in a player.

As yet, little is known about the possibility of expressing current educational practices with LD. This applies to both traditional and more innovative forms of teaching-learning situations. In response, this article examines a number of examples of current educational practice and investigates? Examines? whether they can be expressed with LD. We deliberately chose examples from existing educational practices, firstly because challenging use cases have already be investigated and described in the best practices guide (IMSLD, 2003), and secondly because it is important to identify hurdles which may keep educators and educational designers from using LD to describe their education. Those situations that are difficult or impossible to express with LD are further investigated to see out if a solution can be found. The rationale is that situations for which no solution can be provided might eventually lead to a change in the LD specification.

This article first explains what LD does, and then discusses the design requirements of LD that are applicable to its pedagogical expressiveness. Thereafter we look at the relationship between pedagogical models and LD to establish the focus of this study. The method section first explains how the learning material was selected and subsequently introduces the test methods that were used. The methods used are then further elaborated. The results section reports the findings per method. For the problems identified in the result section, solutions are then provided and conclusions are drawn.

What does IMS LD do? To explain what LD does, we can look at its underlying metaphor: the script of a theatrical play. What we see as a spectator in a theatrical play is a stage, stage properties, and actors (Koper & Olivier, 2004). Usually the stage portrays a scene in which the play takes place, e.g. if the play takes place in the streets of 18th century London, the stage would be decorated with typical 18th century items such as street lights, and the background would show buildings in the style of that time. The actors in the play are given a script containing their lines. Actors cannot however say these lines whenever they want; the script also specifies the order in which the lines must be said. The play may be subdivided into smaller parts called acts. Usually an act deals with just one event or part of the story which is in itself a small play. When an act is finished, the actors usually change and/or the staging is changed. The script combines all the above information and shows the order in which the acts are performed. The act defines which actors have to say what lines, and the staging in which the act takes place.

In LD the play is placed in the *method* section as shown in figure 1 and its function is similar to the theatrical play script. The LD play contains the acts to be carried out in the order listed. An act defines who (which role) has to perform which activity or set of activities. As such, the method is the link between all the components of LD; it coordinates the roles, activities and the environments associated with the activities. All the other concepts of LD are referenced, directly or indirectly, from the method. The role-parts within an act link each role to an activity. The activity provides a description of what each role has to perform and what environment is at its disposal. In an act there can be more than one role active at the same time, as in a theatrical play where there can be more than one actor on the stage at the same time. The activities that are simultaneously performed by different roles are synchronised by the act, meaning that if one of the role-parts finishes an activity before the other role-parts, the next act can only become active if all the role-parts of the previous act are finished unless properties or other more advanced features are used.

```
method
      play*
         act*
            role-parts*
               role-ref
               activity-ref
       conditions
metadata
```

Figure 1. The method section of LD that contains the play (an asterisk * means that an element may occur more than once)

The method section of LD can refer to these components directly or indirectly:

- Roles
- Activities
- Environments
- Notifications

In LD there are two predefined *roles*, a learner role and a staff role. Each one of these roles can be further specialised into sub-roles. For example if the course is about designing buildings, one learner could play the role of an architect and another learner could play the role of a metal construction expert. Similarly the staff role can be sub-divided. Each role can later be assigned to different activities.

Activities in LD are associated with a role in a role-part, and they contain the actual instruction for a person in that role. If the activity is directed at a learner and aims to achieve a specific competence it is referred to as a learning activity. The other possibility is that an activity represents a support activity. Typically, support activities are performed by a person in a staff role, but learners may also be supported by their peers. Furthermore, activities appear as single activities or they can be grouped in structures in a way that they must be carried out sequentially or partially ordered.

Environments are where learning objects and services are located. Learning objects are typically used by learners when performing an activity, but these objects (eg. dictionaries) form no part of the activity description itself. Services are used to provide facilities that are helpful for completing activities. Examples of frequently used services are the conference service and mail service. Environments are linked to activities or activity structures.

There are three levels (A, B and C) of implementation and compliance in LD. Level A contains the vocabulary to support pedagogical diversity. All the concepts explained above form part of LD Level A as shown in figure 2. Level B adds Properties and Conditions to level A, which enable personalisation and more elaborate sequencing and interactions based on learner portfolios. Level B can be used to direct the learning activities as well as record outcomes. Level C adds notifications to Level B.

Conditions are placed in the method section and have the form of If-Then-Else rules. The 'If' part of the condition uses Boolean expressions on properties that are defined in the component section. Conditions can be used to fine tune the path a learner can take through a course or to personalise a course against some predefined characteristics. For example, a course can be adapted to a learner's learning style, showing only visual learning objects to visual learners and verbal learning objects to verbal learners. A course can also be adapted to a learner's prior knowledge: if learner x has prior knowledge on topic y then let this learner start with activity z instead of activity b.

```
learning-design
   title
   learning-objectives
   prerequisites
   components
      roles
         learner*
         staff*
      activities
         learning-activity*
            environment-ref*
            activity-description
         support-activity*
            environment-ref*
            activity-description
         activity-structures*
            environment-ref*
      environments
         environment*
            title
            learning objects*
            services*
            environment-ref*
            metadata
method
      play*
         act*
            role-parts*
               role-ref
               activity-ref
metadata
```

Figure 2. The main components of LD Level A

Properties are containers that can store information such as a learner's progression in a course (completed activities), a learners' learning style, results of tests, and also learning objects that where added during the teaching-learning process as an outcome of an activity (e.g. reports, papers, video registration of a performance). Properties can be either local or global with respect to the run of a unit of learning. A run means that the generic unit of learning is made concrete for one specific group of learners. Local properties are only available within a run of unit of learning and they can be used to store data temporarily. Global properties are also available outside a specific run of a unit of learning and can be used to store information such as data in a learner's portfolio so that it can be used in another run of a unit of learning.

Besides the condition mechanism, LD Level C also contains a *notifications* mechanism for making new activities available. Notifications can be triggered by a change to a property value, the completion of an activity, or a condition that evaluates to true. The notification makes a new learning activity or a new support activity active for a role or it sends a message to another person. The person who triggered the notification is not necessarily the same as the person who needs to be notified. Notifications can be useful if the input for an activity depends on the outcome of another activity. For example in a collaborative task that is geographically dispersed, the results of a task at location A may be used to perform a task at location B.

The unit of learning

The primary use of LD is to model units of learning (UOL) by including the Learning Design in a content package, such as an IMS Content Package. IMS Content Packages describe their content in an XML document called the 'package manifest'. The Manifest may include structured 'views' into the resources contained in that package; each 'view' is described as a hierarchy of items called an 'organization'. Each item refers to a Resource, which can in turn refer to a physical file within the package. It can however also refer to an external resource. Figure 3 depicts the entire IMS Content Packaging conceptual model.

To create a unit of learning, LD is integrated into an IMS Content Package by including the LD element as another kind of organization within the <organizations> element as shown on the right side of figure 3.

The LD element of the unit of learning includes the elements that represent the conceptual model that was briefly outlined before. The details of all the LD elements can be found in the Information Model document (IMSLD, 2003), together with their behavioural specifications.

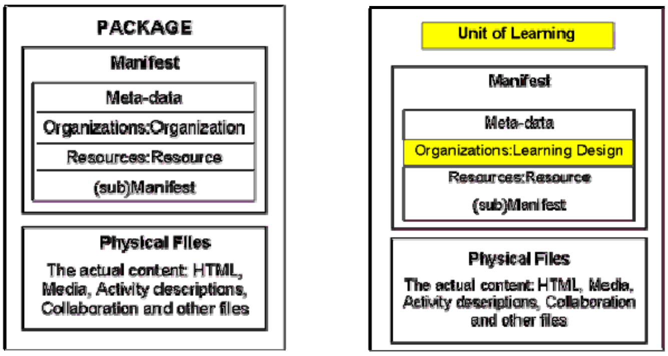


Figure 3. The figure on the left shows the structure of an IMS Content Package. The figure on the right shows the structure of a Unit of Learning, composed by including a Learning Design within the Organizations part of IMS Content Packaging

The concept of LD can be summarised as follows. A person gets a role in the teaching-learning process, this role can either be the role of a learner or staff. For a role, outcomes are stated as learning objectives, these outcomes are to be achieved by performing learning activities for learners, or support activities for those in a staff role. During the performance of activities, if learning objects or services are needed then these are placed in the environment embedded in the activity. Which role has to perform which activity and at what moment in the teaching-learning process is specified by the LD method either through conditions or by means of notifications. The LD model shown in figure 4 is based upon the pedagogical meta-model which will be explained later.

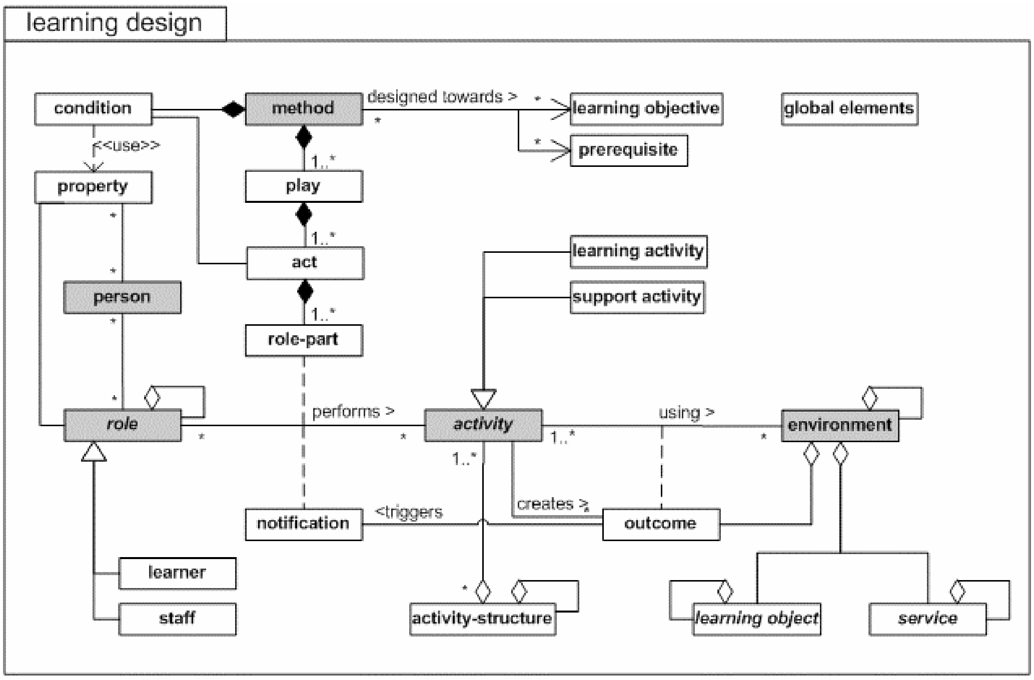


Figure 4. Semantic model representing the learning design of a unit of learning

Requirement of pedagogical expressiveness

When the Educational Modelling Language (EML, 2000; Hermans, Manderveld, & Vogten, 2004) was developed, an extensive list of requirements was drawn up (Koper & Manderveld, 2004). EML was selected as the base from which to develop the LD specification. Most of the changes made to EML had no effect on the conceptual model (Koper & Olivier, 2004) with the exception of test assessment elements which were removed. LD also has a greater focus on online delivery than EML. We will use some of the original EML requirements to define the meaning of pedagogical expressiveness.

In the set of requirements the three requirements listed below dealt explicitly with the design of education:

1. The formal language must be able to describe units of learning based on different theories and models of learning and instruction (*pedagogical flexibility*).
2. The formal language must be able to fully describe a unit of learning, including all typed learning objects, the relationship between the objects and the activities and workflows of all students and staff members using the learning objects (*completeness)*, regardless of whether these aspects are represented digitally or non-digitally.
3. The formal language must be able to describe personalization aspects within units of learning so that content and activities within units of learning can be adapted based on the preferences, prior knowledge, educational needs and the circumstances of users. In addition, control must be able to be given to the student, staff member, computer or designer as required (*personalization*).

Other requirements dealt with technical issues that are beyond the scope of this article.

Pedagogical expressiveness is defined as the ability of a modelling language to describe all types of teaching-learning situations (*pedagogical flexibility*) including the needed flexibility to adapt the UOL to predefined criteria or situational circumstances (*personalization*). The modelling language must be able to describe all learning objects that occur and their relation with the teaching-learning process (*completeness)*. To define pedagogical expressiveness, the three requirements stated above will be used.

To evaluate the pedagogical expressiveness of a UOL it is necessary to narrow the definition of a UOL. The UOL itself has no boundaries as to what it can describe. A UOL could be as large as an entire curriculum of a four-year course or as small as just one learning activity of 15 minutes. To define which part of the teaching-learning process will be further investigated, the following section will consider different pedagogical models and how these relate to LD.

Pedagogical models

During the development of EML a pedagogical meta-model was developed. A pedagogical meta-model is an abstraction of pedagogical models. This means that pedagogical models could be described (or derived) in terms of the meta-model. The reason for developing a meta-model was to have a model that was neutral with respect to different approaches of learning and instruction. Neutrality in this context means that specific pedagogical models, like problem-based learning models or collaborative learning models, should be able to be expressed using the meta-model with the same ease.

Models obtained from the literature were studied (see Koper, 2001; Koper & van Es, 2004) in three major streams of instructional theories and models (Greeno, Collins & Resnick, 1996):

- empiricist (behaviourist)
- rationalist (cognitivist and constructivist)
- pragmatist-sociohistoric (situationalist).

These instructional theories have different views on topics such as: knowledge, learning, transfer and motivation. The three streams of instructional theories can be very helpful to map theoretical or practical models of learning and instruction. To evaluate the pedagogical flexibility that was identified above, these three major streams were used. To explain how pedagogical expressiveness was investigated we need to elaborate on the relationship that exists between the LD specification and the pedagogical models as shown in figure 5. The abstract pedagogical models and instances of these abstract models shown on the left side of the figure, are represented by either the UOL schema or parts of the whole schema shown on the right side of the figure. On the horizontal level the abstraction level of the pedagogical models correspond to the UOL schema (instances).

The pedagogical meta-model is an abstraction of pedagogical models and contains commonalities found between several pedagogical models. The pedagogical meta-model is expressed as a Unit of Learning schema containing all the elements of the pedagogical meta-model and restrictions on their usage, as shown in figure 4. The purpose of an XML Schema is to define the legal building blocks of an XML document, like a DTD. An XML Schema defines elements, attributes, child elements, their order and their numberwhether an element is empty or can include text. A schema can also define data types for elements and attributes and default and fixed values for elements and attributes.

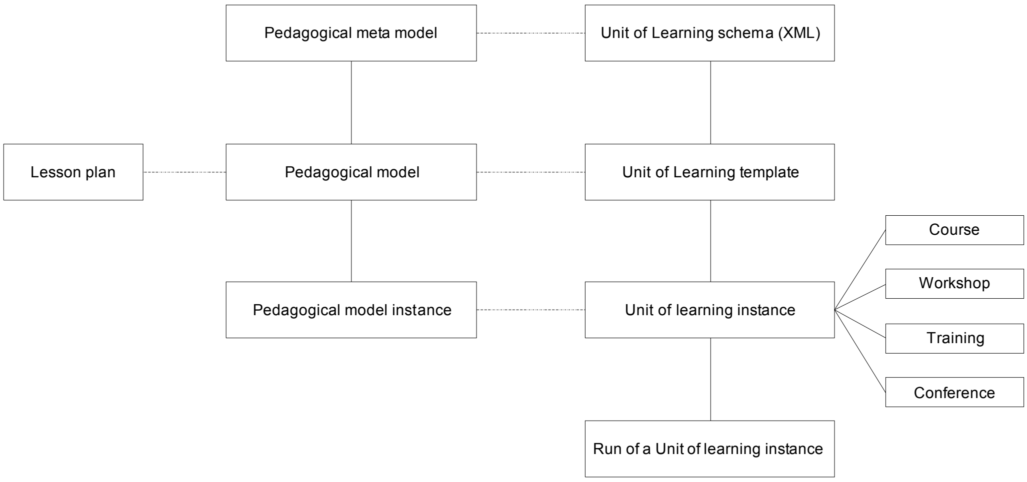


Figure 5. Relation between the pedagogical models and LD

The LD schema is used to validate instances of units of learning (UOL) that are created with an LD editor. Validation of an instance of a UOL means that the document is checked against the rules stated in the schema, for example that the structure of the document is correct, that multiplicity rules are followed and that references to learning objects and services are correct. Though our intention is to evaluate the pedagogical meta-model represented by the? UOL schema, this approach would not be very fruitful because of the high level of abstraction. Also, the scope of the UOL schema is too broad to evaluate because only the correctness of an UOL instance is validated, nothing can be said about the meaningfulness of the document for the teaching-learning process. Therefore we must take a closer look at pedagogical models that served as input for the development of the meta-model, and which are expressed at a lower abstraction level.

Pedagogical models were analysed and abstracted to derive the pedagogical meta-model. A pedagogical model is defined as a method that prescribes how a class of learners can achieve a class of learning objectives in a certain context and knowledge domain. Pedagogical models are inspired by theories on learning and instruction. Examples are learning Spanish as a second language, acquiring mathematical skills for engineering, or how to plead in someone's defence during a trial. A pedagogical model can be represented as a Unit of Learning template in XML. Such a template imposes further restrictions upon the Unit of Learning resulting in a structure that is unique for each? pedagogical model. The rules of a template may for example state that a learning activity is always followed by a self-test and a learning activity always has a conference service defined in the environment. By defining a template, course designers are helped to implement a specific type of instruction such as problem-based learning.

Closely related to pedagogical models are lesson plans that also describe how learners can achieve a set of learning objectives but in a less restrictive form than pedagogical models. Lesson plans do not necessarily have a strong relation with learning theories. Teachers who are familiar with a certain topic often create lesson plans for their fellow teachers and may make these publicly available.

A pedagogical model instance is the application of a pedagogical model with specific learning objectives in a specific domain. It is more detailed than a pedagogical model in the sense that content and assignments are made concrete. For a Unit of Learning, this means that resources are added to the design.

A run of a UOL instance implies the concrete assignment of learners and staff to a course and the scheduling of a time and location. If services are defined in the UOL, applications to handle these services are also prepared, with the settings defined in the UOL. If properties are defined in the UOL, instances of these properties are created in the system database and learner portfolios.

Referring again to the theatre metaphor, we can compare the pedagogical model to the complete script that outlines the whole play. An instance of a pedagogical model would then contain the play script, all the stage attributes, the decor, and the lighting. When a run of a UOL is created, it means that the play is programmed for a specific theatre, actors are trained to perform the play, tickets are sold to the audience, and the theatre stage is prepared.

For this investigation, learning material from current education was used. Current education covers all types of education ranging from primary school to higher education and continuing education. To be able to generalise the results, no restrictions were imposed on the type of education. The learning material investigated had to provide enough information so that all the aspects found in the requirements must also be included in the learning material. For this reason we decided upon using lesson plans as learning material for the following reasons. Lesson plans usually describe how a series of lessons or a single lesson should take place. It is expected that curriculum structures are not more complex than those structures used within a lesson. Lesson plans provide guidelines to developers of learning materials based on instructional theories which have a closer relation to pedagogical models than concrete lesson materials. Personalisation is expected to have more impact on materials used within a lesson than on a course or a curriculum.

Method

Selection of learning material

We used English language lesson plans that were available on-line from twelve separate websites (see table 1). The lesson plans offered on these websites covered the full range of education, from kindergarten to university. A total of sixteen lesson plans were drawn at random from the selected web sites, covering various subjects. We chose a random selection in order to get a representative sample of lesson plans currently used in education. Table 2 shows the lesson plan title, subject and a reference to the website from which it was drawn.

Table 1: Websites that offered lesson plans with an approximate number of lesson plans offered and the URL of the web site

Web site reference	Web site name	Available lesson plans	URL
	The Gateway to Educational Materials	36,000	www.thegateway.org
	LessonPlanz.com	300	www.lessonplanz.com
	PBS teachersource	4500	www.pbs.org
	Lessonplan search	2300	www.lessonplansearch.com
	Merlot	9500	www.merlot.org
	Statistics Canada	400	www.statcan.ca
	National Grid for learning	190	www.ngfl.gov.uk
	Teachers.net	1000	teachers.net/lessons/
	SMETE	300	www.smete.org/smete
	Knowledge Agora	350	www.knowledgeagora.com
	Retanet	65	ladb.unm.edu/retanet
	National learning network materials	70	www.nln.ac.uk/materials

Table 2: Selected lesson plans including the subject the lesson plan covers and a reference to table 1 to indicate the web site where the lesson plan can be found

Lesson plan title	Subject	Reference
Tongue Twisters	Language arts	2
Lincoln's Secret Weapon	Science & Technology	1
Rhythmic Innovations	Mathematics	3
Consider Copying	Science & Technology	1
The Darien Adventure	History	7
Carnival Safety Success	Language arts	5
Exploring Disability	Drama	2
Ecosystems And Well-Being	Health, Science, Geography	6
Kermit The Hermit	Language arts	1
Inventions	Language arts, Humanities	10
Cracking Dams	Science & Technology	2

The Works Progress Administration And The New Deal	Social studies	3
Learning Microsoft Excel	Science & technology	5
How Do People Express Their Faith Through The Arts?	Social studies	4
Eyes In The Sky	Science & technology	9
A Pittsburgh Memory	Language arts & social studies	13

All 12 websites used subject categories (i.e. mathematics, physics, biology) to present their lesson plans. We followed the procedure as shown in figure 6 to select a lesson plan from one of the web sites.

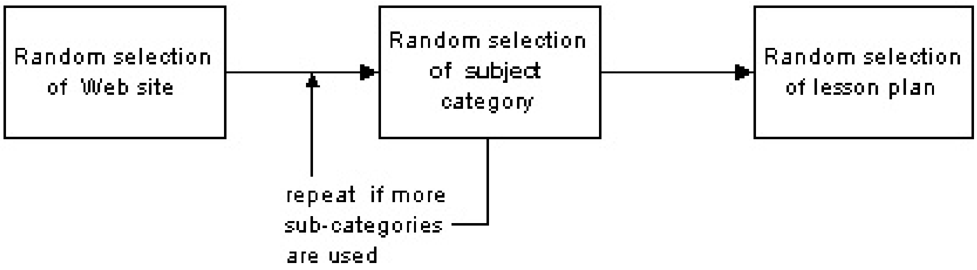


Figure 6. Procedure followed to select a lesson plan from one of the 12 web sites

For example, first a random number between 1 and 12 was generated to determine the web site to pick the lesson plan from. Assuming the generated number was 1, and then according to table 1 the lesson plan would be taken from the web site of "The Gateway to Educational Materials". That web site used 12 subject categories (see figure 7) to organise their lesson plans.

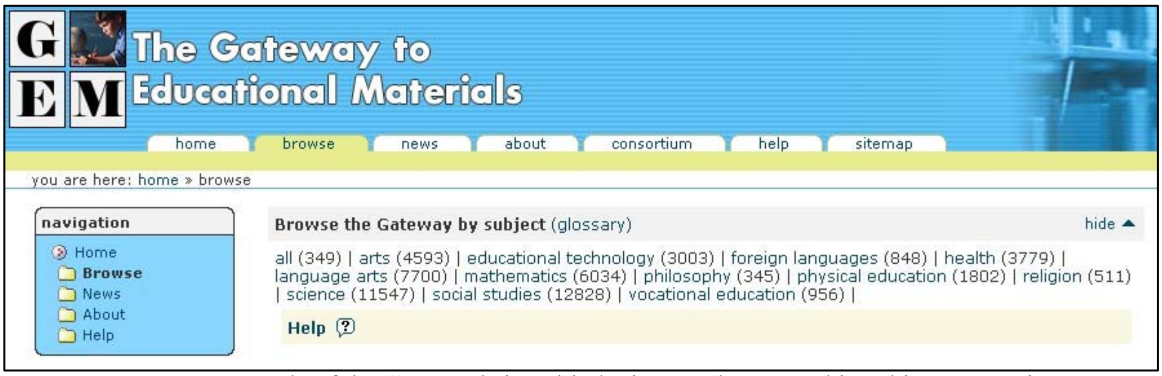


Figure 7. Example of the GEM website with the lesson plans sorted in subject categories

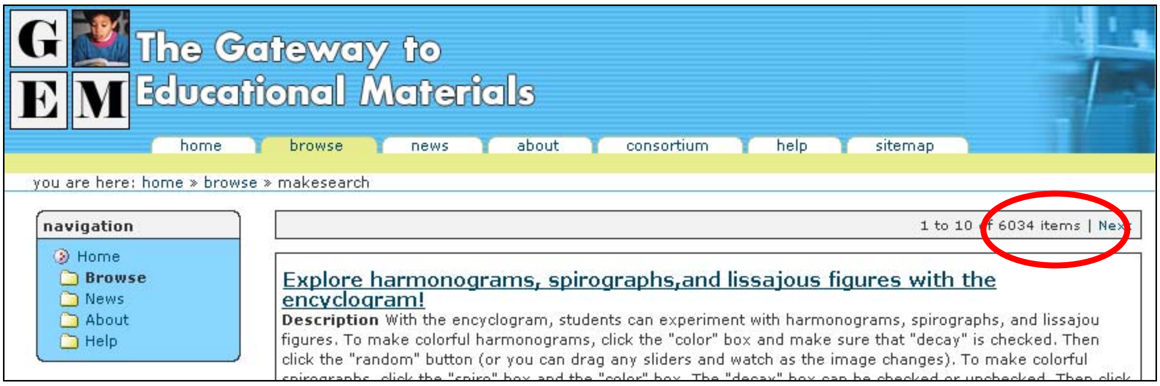


Figure 8. The list of lesson plans found in the mathematics subject category. This category contains a total of 6034 lesson plans as indicated with the red circle

Next, a random number between 1 and 12 was generated to determine a subject category, for example 6. The sixth subject category from the list is Mathematics, which contains 6034 lesson plans (figure 8). Finally a random number between 1 and 6034 was generated to determine the lesson plan that would be analysed.

A lesson plan should meet the criteria of having a study duration of at least 1 hour, and contain 2 or more activities. If a selected lesson plan did not meet this criteria, it was replaced by another one using the same selection method.

Methods used to analyse the lesson plans

To investigate whether the selected lesson plans can indeed be expressed fully with LD, we need to elaborate first on what this actually means. A typical lesson plan describes how learners can reach a learning objective or set of learning objectives. A lesson plan is written for a teacher or an educational developer and describes which activities learners and teachers must carry out, the order in which the activities should be carried out, the circumstances under which the activities will be carried out, how learners will be grouped and what materials or technology may be used. A sample lesson plan is shown in figure 9. The whole lesson plan contains an introduction to the problem of the lesson, the tasks a teacher must carry out, a description of the learners roles, process information indicating how learners should proceed through the lesson, a description of materials that may be used or references to required worksheets and some evaluation guidelines for the teacher. These are typical elements for a lesson plan and one can find this information most of the time although the labelling of the information may vary.

Tasks

- Assign each member of the group a role. Each person has the responsibility to lead the parts of the process listed under their role.
- Follow the process below.
- Answer the questions on your worksheet as you proceed.
- Post messages on the bulletin board as directed, particularly to state your group's position on the dam repair or decommissioning at the end of the quest.

Process

Bookmark the Webquest. You should return to this Process at the beginning of each step. Assign roles.
1. The government has told you that there are problems with the Narrows Dam, so you need to gather some basic information about that dam, which is on the Little Missouri River. Look up the Narrows Dam in the National Inventory of Dams (#). Fill in your worksheet about this dam.
2. Next, you must consider what services the dam is providing and how important these are. Go to the Dams section and read about the societal nature of dams. Fill in your worksheet about the services dams provide.
…

Figure 9. Sample of a lesson plan

We used several criteria to determine to what extent the lesson plans could be expressed in LD. First, it should be possible to make a match between the concepts found in the lesson plans and the conceptual vocabulary of Learning Design (See LD information model; IMSLD, 2003). With these criteria the static structure of the lesson plan is mapped onto LD and if learners or teachers are working on activities in parallel the workflow is synchronised. Second, the workflow laid down in the lesson plan must be realised with either the constructs of the conceptual vocabulary (i.e. acts and role parts) or by using conditions and properties. The use of acts only provides a means to realise a linear workflow. If a more dynamic flow is needed, conditions and properties can be used to change the visibility of most of the elements of the conceptual vocabulary, with the exception of an act. If some kind of adaptation or personalisation was identified in the lesson plan together with elements of the conceptual vocabulary, the addition of properties and conditions should suffice to realise it. Finally, if learners or teachers need to be informed when a certain event takes place, or a trigger is required to indicate that either a learner or a teacher must undertake action, than LD has to provide this.

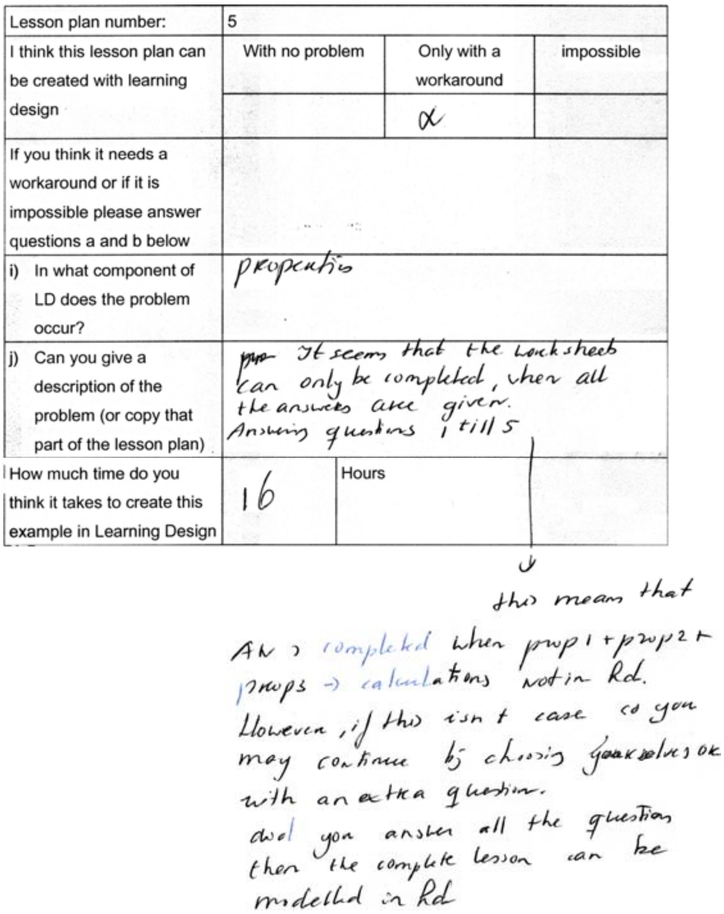
Several methods were used to analyse the lesson plans. Since this was the first time such an investigation was carried out, we also needed to find methods which were efficient yet would provide all the required information. The methods used aimed at gaining insight into the capacity of LD to express teaching-learning situations, rather than a quantitative measure of the difficulties found. The following methods were selected to analyse the lesson plans:

- Expert analysis
- Document validation
- Learning Design coding

These methods highlighted any situation which did not meet one of the criteria. Such a situation could then be labelled as a recoverable error or as a non-recoverable error. A recoverable error was defined as something found in a lesson plan that could not be matched with the conceptual vocabulary; a required condition or property for which there was no clear handle; or a required notification for which no trigger could be provided. A recoverable error can be seen as a weakness in LD that might call for a change or addition to the model. In contrast, a non-recoverable error it is defined as a situation where it was not possible to express a part of a lesson plan with LD at all.

Expert analysis

This analysis method made use of experts that were asked to give their judgement on how easy or difficult it was to create an LD instance of one of the lesson plans. These experts were required to have extensive experience in LD coding and have an awareness of the possibilities the specification offers. For this analysis, we used two LD experts from the Open University of the Netherlands. The experts were asked to rate a lesson plan on a three-point scale ranging from no problems, recoverable error, or non-recoverable error. The experts received brief instructions on how to carry out the rating, but they did not receive any training prior to their rating.



Lesson plan number:	5		
I think this lesson plan can be created with learning design	With no problem	Only with a workaround	impossible
		x	
If you think it needs a workaround or if it is impossible please answer questions a and b below			
i) In what component of LD does the problem occur?	properties		
j) Can you give a description of the problem (or copy that part of the lesson plan)	It seems that the worksheets can only be completed, when all the answers are given. Answering questions 1 till 5		
How much time do you think it takes to create this example in Learning Design	16	Hours	

this mean that AW's completed when prop1 + prop2 + props → calculations not in LD. However, if this isn't case so you may continue by choosing goalsolves ok with an extra question. and you answer all the questions then the complete lesson can be modelled in LD

Figure 10. Example of a lesson plan analysis carried out by an LD expert

When a recoverable or non-recoverable error was identified, the experts were asked to indicate the part of the lesson plan that led them to their judgement. Figure 10 provides an example of an expert analysis.

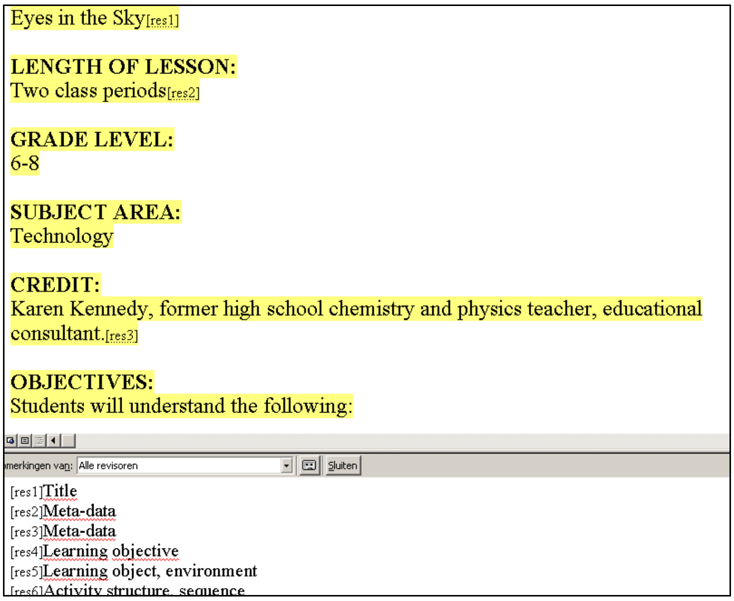
Document analysis

The document analysis method uses a set of procedures to make valid inferences from text. Traditionally, this method has been used in the social sciences to compare texts and search for relationships between them. In this instance, we do not want to compare text documents; we used this method to find similarities between the text in the lesson plan and the LD specification. A central idea in content analysis is that the words of a text are classified into a small number of content categories. (Weber, 1985). Each category may consist of one, several, or many words. Words, phrases, or other units of text classified in the same category are presumed to have similar meanings. The purpose of this content-analysis is to classify parts of a lesson plan according to the vocabulary used in LD. This results in a list of categorised text plus a residue. Residues are thought to be good indicators of a lack of fit of LD.

The procedure followed involved three iterations carried out manually. Firstly, the whole text was read. When text blocks were encountered containing words that could be classified, these blocks would be marked. Secondly, the marked blocks of text were further analysed to classify the text into LD vocabulary concepts. Once the whole text was analysed, the unmarked text became the topic of analysis because that indicated an element that was not available in LD. Further analysis was conducted to reveal if a workaround could be found. A subsection of a lesson plan that was analysed using this method is shown in figure 11.

The analysed lesson plans were also classified according to the main streams of instructional theory (i.e. empiricist, rationalist, pragmatist-sociohistoric). To classify the lesson plans we used the criteria listed by Greeno, Collins & Resnick (1996). They describe instructional theories according to the learning environment in which the learning takes place, the way the curricula are organised, and how learner achievements are measured. The selected lesson plans were rated against the criteria and subsequently assigned to the instructional theory that received the highest rating.

This data was used to investigate the extent to which difficulties in expressing lesson plans with LD are specific to particular pedagogies.


Eyes in the Sky[res1]

LENGTH OF LESSON:
Two class periods[res2]

GRADE LEVEL:
6-8

SUBJECT AREA:
Technology

CREDIT:
Karen Kennedy, former high school chemistry and physics teacher, educational consultant.[res3]

OBJECTIVES:
Students will understand the following:

merkingen van: Alle revisoren Sluiten

[res1]Title
[res2]Meta-data
[res3]Meta-data
[res4]Learning objective
[res5]Learning object, environment
[res6]Activity structure, sequence

Figure 11. A fragment of an analysed lesson plan where the upper section shows the original text with text marks referring to the concepts of the LD vocabulary shown in the lower part of the figure

Learning design coding

The third validation method involved the transformation of the lesson plans into UOLs. To do this we followed the procedure described in the Best Practice and Implementation Guide of LD (IMSLD, 2003). The phases in this procedure are:

1. In the analysis phase, a concrete educational problem (use case) is analysed. The analysis results in a didactic scenario that is captured in a narrative, often on the basis of a checklist.

2. The narrative is then cast in the form of a UML activity diagram in order to add more rigor to the analysis. This is the first design step. The UML activity diagram then forms the basis for an XML document instance which conforms to the LD specification. This is the second design step.
3. This document instance subsequently forms the basis for the development of the actual content (resources) in the development phase. The content package with both the resources and the LD will then be evaluated.

The first phase in the design process was covered by the selection procedure of the lesson plan. Lesson plans provide detailed descriptions of what a lesson should look like. The next phase in the process is the creation of an activity diagram based on the lesson plan. The diagram shows activities organised per actor in so-called swim lanes. In a swim lane, all the activities for a role are listed sequentially. The flow through the whole diagram is indicated by a start node at the beginning and an end node indicating when the lesson is completed with lines connecting the activities. Activities that are placed at the same horizontal level are carried out at the same time but by different roles. An example of such an activity diagram is shown in figure 12.

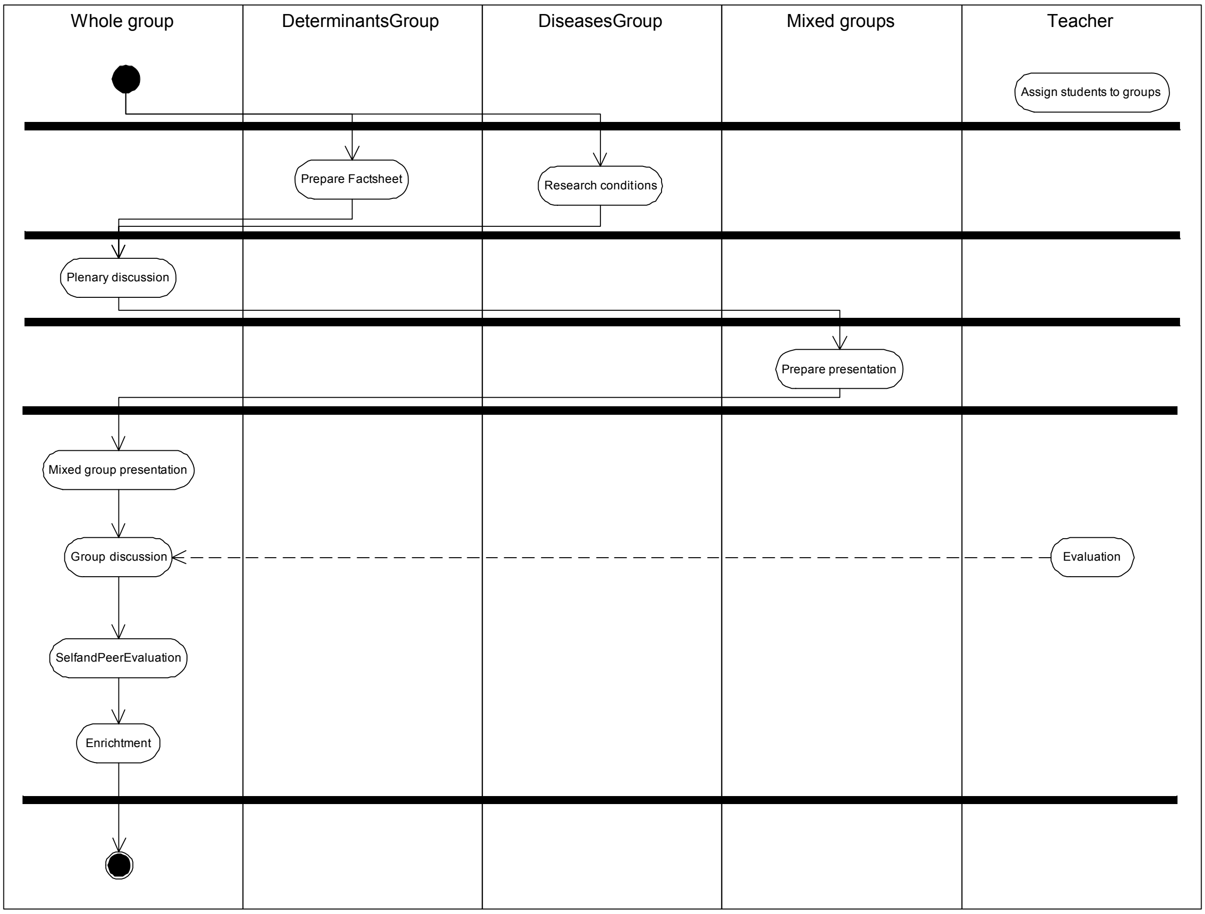


Figure 12. Example of a lesson plan worked out as an UML activity diagram

A Learning Design instance was then created from the activity description. During the modelling process, the location and types of difficulties encountered was systematically logged. Figure 13 shows an example of a lesson plan coded in LD. An instantiation of the LD instance could be created and played in an LD compliant player to see the results.

Results

Expert analysis

Two experienced Learning Designers were asked to estimate the level of difficulty experienced with expressing a lesson plan in LD, using a three-point scale. The estimation of options the experts had were (a) no problem, (b) recoverable error, (c) non-recoverable error. The initial rating results showed only a slight inter-judgement agreement (Cohen's kappa $\kappa < .21$) between the experts. Analysis of the comments the experts provided along with their judgement revealed that one expert estimated all classroom-based lesson plans as lesson plans with a recoverable error. If a lesson plan was judged as having a recoverable error based only on a classroom situation then it was recoded as having no problem, because LD is not limited to on-line or distance education.


```
- <organizations>
  - <imsld:learning-design identifier="learningdesign1" level="C" uri="http://www.alfanet.portal-ace.com">
      <imsld:title>How environment affects the health of Canadiens</imsld:title>
    - <imsld:components>
      - <imsld:roles>
        + <imsld:learner identifier="WholeGroup" create-new="allowed">
        + <imsld:learner identifier="DeterminantGroup" create-new="allowed">
        + <imsld:learner identifier="DisseasesGroup" create-new="allowed">
        + <imsld:learner identifier="MixedGroups" create-new="allowed">
        + <imsld:staff identifier="Teacher" create-new="allowed">
        </imsld:roles>
      + <imsld:activities>
      + <imsld:environments>
      </imsld:components>
    - <imsld:method>
      - <imsld:play identifier="play1" isvisible="true">
          <imsld:title>Play1</imsld:title>
        - <imsld:act identifier="act1">
            <imsld:title>Act1</imsld:title>
          - <imsld:role-part identifier="Part1a">
              <imsld:title>Part1a</imsld:title>
              <imsld:role-ref ref="DeterminantGroup"/>
              <imsld:learning-activity-ref ref="PrepareFactsheet"/>
            </imsld:role-part>
          + <imsld:role-part identifier="Part1b">
          </imsld:act>
        + <imsld:act identifier="Act2">
        + <imsld:act identifier="Act3">
        + <imsld:act identifier="Act4">
        </imsld:play>
      </imsld:method>
    </imsld:learning-design>
  </organizations>
+ <resources>
</manifest>
```


Figure 12. Example of a lesson plan coded in LD

The inter-judgement agreement for the experts was substantial (Cohen's kappa $.61 < \kappa < .8$) after the data was recoded and is shown in table 3. The experts estimated that it would be possible to express all the lesson plans in LD. The category of 'non-recoverable error' is therefore not shown in the table.

The experts agreed on three of the five recoverable errors identified in the lesson plans, with each expert finding one additional recoverable error on which they did not agree.

Table 3: Difficulty to express a lesson plan based upon the expert analysis

Lesson plan number	Expert 1		Expert 2		Expert agreement
	No problem	Recoverable error	No problem	Recoverable error	
1.		x	x		
2.	x		x		x
3.	x		x		x
4.		x		x	x
5.	x		x		x
6.	x		x		x
7.	x		x		x
8.		x		x	x
9.	x		x		x
10.	x		x		x
11.	x		x		x
12.		x		x	x
13.	x		x		x
14.	x		x		x
15.	x			x	x
16.	x		x		
Total	12	4	12	4	14

Document analysis

In total five recoverable errors were found with the document analysis; non-recoverable errors where not found. The results of the document analysis are shown in table 4. The non-recoverable errors category is not shown.

Table 4: Difficulty to express a lesson plan based upon the document analysis and classification of a lesson plan to an instructional stream

	Error type		Instructional stream		
Lesson plan number	No problem	Recoverable error	Empiricist	Rationalist	Pragmatist-sociohistoric
1.		x	x		
2.		x		x	
3.	x		x		
4.		x			x
5.	x			x	
6.	x		x		
7.		x			x
8.	x				x
9.	x		x		
10.	x				x
11.	x				x
12.	x				x
13.	x		x		
14.	x			x	
15.	x			x	
16.		x		x	
Total	11	5	5	5	6

Pedagogical flexibility

The difficulties in expressing the lesson plans in LD were categorised according to the major streams of instructional theories as shown in table 5. These data were not analysed further because the number of observations were too small to obtain sufficient power for statistical tests.

Table 5. Difficulties expressing lesson plans in LD, organised according to major streams of instructional theory

	Error type	
Stream of instructional theory	No problem	Recoverable error
Empiricist	4	1
Rationalist	3	2
Pragmatic-sociohistoric	4	2

Table 6: Difficulties found during the lesson plan coding

	Error type	
Lesson plan number	No problem	Recoverable error
1		x
2		x
3	x	
4		x
5	x	
6	x	
7		x
8	x	
9	x	
10	x	
11	x	
12	x	
13	x	
14	x	
15	x	
16		x
Total	11	5

Learning design coding

During the coding of the lesson plans, the same difficulties expressing a lesson plan in LD were found as during the document analysis (table 6). Occasionally, differences were found with the document analysis but these differences were related to the interpretation of the lesson plan work flow rather than with the ability to express part of the lesson plan in LD. These differences were not systematically logged.

Solutions to the identified problems

The results of the test showed that some of the selected lesson plans contained elements for which LD did not provide a standard solution, and an adequate way to describe such cases is required. No evidence was found that LD was not suitable for describing contemporary education, since no situations were found to be impossible to express using LD. It is of interest to take a closer look at those situations that were not possible to describe directly with LD. All cases with a judgement 'recoverable error' either in the document analysis or in the expert analysis will be discussed next and a suggestion for how to code these cases is given.

Case 1

The first situation dealt with passing a piece of work from one student to another within a group as illustrated in Figure 14.

> Students: *Pass your paper* to the person on your right. Write one answer for number (3) for the paper you just received. Your answer must begin with the first sound in the person's name (e.g. Mary - made a mess). Then *pass the paper again* and write an answer for (4), again using the same sound that begins the name. Continue doing this until all the blanks on all the papers are full. You should have lots of different answers from all the people in your group when your paper comes back to you!

Figure 14. Passing on a learning object within a group among all group members

LD allows the creation of groups by defining roles, and learning objects can be created and placed in an environment. A person in a role can be notified as soon as a person in a role has completed some activity. However, the problem at hand is that it is not possible to let a learning object circulate among other learners within the same role as is the case here.

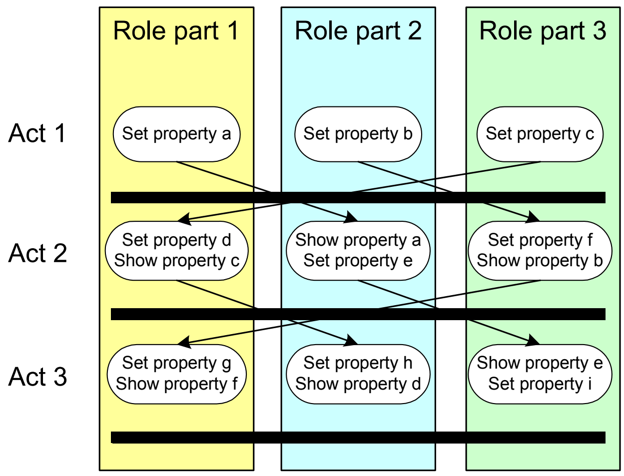


Figure 15. LD implementation for a circulating learning object

The solution developed for this case uses properties and sub-roles to show or set a property value as illustrated in figure 15. For a group of three learners, three role parts are created. In the first act each learner fills in a field and thereby setting an LD property. Once all learners have completed this activity, the next act becomes active. Now each learner sees the property value set by another learner to which the learner has to respond by filling in a form and thereby setting a new LD property. When all learners have completed this activity, act 3 becomes available. In this last act, the learner sees the property value of the remaining learner and responds to the information filled in by the previous learner.

The solution provided works fine as long as the number of learners in a group are known beforehand, is fixed, and a group contains the required number of learners; the workflow must be adapted to the number of learners.

Case 2

The lesson plan where this situation occurred dealt with diving tables that divers need when they use compressed air to dive. See figure 16 for the text fragment of the lesson plan showing the problem. This type of situation could also occur in other situations where safety precautions must be followed, as in a construction task or a laboratory experiment.

> **Important Note**
> Diving can be a dangerous sport, which is why it's one of the few recreational activities that certifies participants. The Diving Table on page 8 is loosely based on dive tables used by the U.S. Navy without decompression stops and is included here for the purpose of introducing the basic concept of diving physiology. Its utility is limited to this purpose only. Potential divers must receive proper instruction by enrolling in a diver training program offered by recognized certification agencies.

Figure16. Warning information prior to a learning activity

LD has no specific method for representing this type of information, but there are other ways to reach a similar effect. The easiest way to warn learners of some danger is to include a warning message within an learning activity as instructional text or graphics. An alternative is making use of notifications. As soon as a learner starts a learning activity that needs a warning message, a property is set <*datetimeactivity-started*> which is compared with the date and time the activity was published. When the property value that was set is of a later time and/or date then the published date, a *notification* is send to the learner containing the warning or safety precautions.

Case 3

In two lesson plans, a situation occurred where a randomisation mechanism was needed. In one lesson plan students were required to pull a piece of paper from a bag (see figure 17), and the other plan used randomisation to provide a student from the group with a special task (see figure 18).

> Have one student cut apart Activity Sheet 1 and place the slips of paper in the paper bag.
> Group students in pairs. Allow each pair to draw a slip of paper from the bag and discuss the situation described.

Figure 17. Warning information prior to a learning activity

> **A)** Run a lottery to decide who will play the part of the disabled person, small pieces of paper are pulled from a bag and one is marked with a cross.
> **B)** Ask the class to open their papers together. What are their feelings before they open the paper? After finding out whether it is them or not, how do they feel?

Figure 18. Random setting of personal property

In LD there is no in-built mechanism to provide randomisation. For the problem of selecting an assignment using LD, an activity selection could be created to set the number of activities when the selection is considered completed. That is, if the selection contains ten activities the learner may be required to complete only two before the whole selection is considered completed. One could also construct a web page (external service) to inform learners what to do. The learning activity then only contains a link to this web page.

Solving the problem of assigning one learner out of a group of learners with a special characteristic can also be done by LD but not randomly. On this occasion the characteristic did not involve performing different learning activities. Therefore a tutor could set a local-personal property *<locpers-property>* with one of the learners in a role. If a learner has to be assigned to a different role, a course administrator must assign this role to one of the learners and might use the same procedure as described in the lesson plan.

Case 4

On three occasions groups needed to be formed dynamically once a lesson was already started. One lesson plan made use of two types of groups, each containing their own learning activities. At a certain moment, new groups needed to be formed based on the old groups as shown in figure 19. In principle, this means that if there were initially two types of groups, A and B, new groups needed to be formed out of these groups with a mix of members from, both former groups. Another lesson plan instructed learners to form their own group (see figure 20), which is no problem in a class situation but not so straightforward using an e-learning platform. The third lesson plan instructed the teacher to divide the whole class into groups as shown in figure 21.

Part A
Divide the class into groups with two or three students in each group. Half of the groups will be Determinants Groups and the other half will be Diseases Groups.
Part B
Form new groups connecting the relevant Determinants Group with the corresponding Diseases Group. Each combined group shares Fact Sheet information and prepares an oral presentation for the rest of the class.

Figure 19. Forming new groups out of previous groups

Give students a few days to think about what they will include in the skit and with whom they will work. Let them choose their partners to write and enact a skit that summarizes life in the 1930's.

Figure 20. Formation of groups by learners

Divide your class into groups, and ask each group to create an aerial map of an area surrounding and including your school (without, of course, using any technology but their own imaginations).

Figure 21. Warning information prior to a learning activity

LD does not provide a mechanism for a learner to assign himself to a group. How learners are assigned to a role depends on the implementation of the runtime environment and the administrative system that is used.

Role population during delivery is very similar to the initial role population in the production stage. The main difference is the actor using this functionality. During the production stage, role population is considered to be an administrative task, dividing all assigned users of a run into either the staff or the learner role. The user does not require any knowledge of the LD itself.

During the delivery stage, the assignment of roles is further refined depending on the role definitions in the LD. The user who performs this task needs knowledge of the LD and also knowledge of the users. For the example in figure 20, the lesson plan states that students themselves should form new groups. Students can discuss with each other to determine with whom they want to work with and then individually assign themselves to a role. For the examples in figure 19 and 21 the teacher must be able assign learners to a sub-group. The runtime system needs to take care of these requirements in order to make these lesson plans work. The runtime system should also provide a mechanism to the user that allows switching of roles. Switching roles implies that the LD is viewed from a different perspective.

Case 5

Another teaching technique found in one of the lesson plans is often used in workshops and seminars, and provides an overview of existing knowledge, and what they want to learn during the session. Afterwards what students actually learned during the session is evaluated. In this lesson plan this technique was called a KWL chart, see figure 22.

Begin a class discussion by using a KWL chart [what the students know (K), what the students want to learn (W), and what they did learn (L)]. Elicit from the class what they already know about the depression, Roosevelt's New Deal, and the WPA.

Figure 22. Learner inventory form (KWL chart)

The illustrated problem can be approached in two ways. The first approach uses the conference service as defined in LD and the second approach uses properties and the monitor service of LD. Using the conference service makes it possible to assign different rights to the learnerssuch as participant, observer, moderator, or a conference-manager. One of the learners or the teacher can be assigned to the role of the moderator who collects the responses of the participants to the questions. This role is then asked to fill in the KWL chart and transfer the responses into LD local properties. Local properties are available to everyone who is subscribed to a run of a unit of learning using the show property value. The second approach uses global personal properties to enable every learner fill in a value of the KWL chart on their own. If a monitor service is created, the values entered by all learners can then be displayed to everyone.

Case 6

While many of the lesson plans investigated contained instructions for teachers on how to use the lesson plan, one lesson plan consisted almost entirely of instructions and suggestions for teachers.

Introduction
This unit was developed from the standpoint of a self-contained classroom where the same teacher would deliver the English, Reading and Social Studies instruction. The reading selections, activities and lessons are designed for fourth and fifth grade students, but can be adjusted to meet a variety of reading levels. There is no suggested timeline. This unit can be carried out in its entirety or dispersed throughout the year. It can be integrated with any literature program that is supported by student writing.
….
The reason I chose memoir writing is because it deals with two difficult issues facing all writers (1) what to include and (2) what not to include. The author, Maya Angelou, once said, "This is a good 20 page paper, if I had had more time it would have been an excellent 10 page paper." In her book, How I Became a Writer, Phyllis Reynolds Naylor shares her view on the evolution of her work, "I've learned to let a manuscript sit for a few days or weeks, then read it again. …

Figure 23. Notes that serve as background information for the teacher who intends to use this lesson plan

Currently there is no specific LD activity to covers this need, but there are two ways to achieve a similar result. In principle the information stated in figure 23 provides information about a lesson plan and is therefore meta-data. A meta-data specification that can be used for this purpose is IMS Meta-data for which a name space is provided in LD. In IMS Meta-data there is a tag called "description" in the branch of "education" which is may be used to provide comments on the conditions and use of the resource (learning activity in LD). There is however a limitation of 1000 characters for this field. Another way to provide information to a teacher on how to use a lesson plan is to make use of support activities. Although this type of activity is intended to provide activities to support learners, one can also interpret the instructions of the lesson plan creator as support for the teacher who is teaching the course. Support activities containing such teacher instructions can be coupled to a staff role so that only the teacher has access.

Summary

In this test to express a set of lesson plans in LD, we found six distinct cases requiring extra attention. The first case described a mechanism for a collaborative assignment that used a document circulated among the members of a group of learners. The second case described how a message can be shown before an activity is started; in this case, a safety warning. The third case described the use of a randomisation mechanism that was needed to select one member of a group. The fourth case identified the need that groups of learners have to be created at runtime. The fifth case described how the pre-knowledge, learning objectives and achieved learning objectives for a group of learners can be captured of each individual learner and exposed to the whole group of learners. The sixth case described the need to capture instructions from the lesson designer or a fellow teacher on how to use a lesson.

Conclusions

In this evaluation we have taken several lesson plans and investigated how well these plans could be expressed in LD. Although several lesson plans needed a work around, the main educational processes could all be described sufficiently with LD. On all but one occasion the work-around did not influence the overall learning process itself, but a small element of it. Only the workaround described in case 1 affected the main learning process. LD offers services that proved to be useful, such as mail, conference and a monitor. However, specific learning situations might require special services which are currently not offered in LD. For this, LD provides a mechanism to include services developed elsewhere. For example Hernández, Asensio Pérez, & Dimitriadis (2004) have developed a service specifically for computer supported collaborative learning (CSCL). We identified the need for two kinds of services in this test. The first one for a circulation mechanism of a learning object within a group where each member can edit a part of the learning object, and the second one is a randomly selected group member who can be assigned to a different role. Also a need exists to form new groups at runtime based on the outcomes of the learning process. The formation of groups at runtime is something which is foreseen in LD but is dependent on the implementation of the runtime environment. Future investigations could also specifically search for the identified problems in a larger number of lesson plans to gain an insight into the scale at which the problems occur.

We used three methods to test the expressiveness of LD because we also wanted to gather information on the effectiveness and efficiency of each method. Of the methods used, the expert analysis was the most efficient. The time spent by the two experts was less than time spent on the document analysis and LD coding. We also experienced that the expert analysis must be conducted with great care. It is necessary that the experts receive training prior to their rating activities so they interpret and rate situations in the same way. The reliability of the results is expected to increase as more experts rate the lesson plans, but this will be at the cost of time efficiency. It was not difficult to find experienced LD coders, but it was difficult to find LD coders that had sufficiently broad experience. The document analysis proved to be more effective and the results more reliable than those of the expert analysis. We draw this conclusion because coding the lesson plans identified no additional work-arounds to those already identified in the document analysis. However, this method is less efficient since it takes about a three times as much time as the expert analysis with two experts. In this test we only used one person to carry out the document analysis. Those carrying out the document analysis need to have the same qualifications as the experts previously mentioned. Finally the LD coding is the most time consuming method. It takes about ten times the amount of time spent on the document analysis to code a lesson plan in LD. This time could be shortened when specific LD editors become available; for this test we used a generic XML editor.

Future tests can make use of this test by further elaborating the methods used and refining the measurements. Document analysis would be the preferred method because it provides a good balance between efficiency and effectiveness. Quantitative measures require the analysis of many more lesson plans than analysed in this test. To achieve this, the use of tools for automated evaluation of text would be very useful. This would also enable testing to determine if the pedagogical flexibility requirement is met by LD as the results of this investigation were not conclusive enough.

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An Analysis of Interaction and Participation Patterns in Online Community

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ABSTRACT

This paper presents findings from the pattern of participation and discourse analysis of the online interaction among in-service teachers in the teacher training institute in Singapore. It was found that the teachers formed a knowledge-building community and jointly discussed issues related to integrating information technology into the classroom. There was evidence that teachers formed a socially cohesive community and their participations were active. However it was found that in-depth and sustainable online interaction were lacking. The authors suggest searching for ways to promote deep and sustainable online interaction, especially in terms of getting participants to detect the gap in ideas and challenging assumptions.

Keywords

Knowledge building community, Computer-supported collaborative learning, Online interaction

Introduction

In this information age, lifelong learning and collaboration are essential aspects of most innovative work (Stahl, 2000). It is imperative for educators to nurture in our next generation learners the habit of community participation and collaboration. Computer Supported Collaborative Learning (CSCL) systems are the tools designed to support the building of shared knowledge and knowledge negotiation (Stahl, 2003). However, implementing CSCL systems into classroom teaching and learning is a complex process that involves substantial teachers' learning. This study is based on a straightforward assumption that if teachers are unable to demonstrate substantial knowledge building interactions online among themselves, it is doubtful that they will be able to implement CSCL effectively. To date, there seems to be few studies that focus in the analysis of teachers' online discourse (Zhao & Rop, 2001).

Knowledge-building Community

A Knowledge-building Community (KBC) is a group of learners committed to advancing the group's knowledge of some shared problems through collaboration (Hewitt, 2001). It resembles knowledge creation teams such as research and development teams in scientific community or the commercial world. Supported by an asynchronous communication platform known as Knowledge Forum™ (KF™), the KBC is a social-constructivist oriented pedagogical model developed by Scardamalia and Bereiter (1996). It builds on social-cultural theories of learning that view learning as a process of participating and interacting in a community of practice (Vygotsky, 1978; Greeno, 1998; Lave & Wenger, 1999). Given this general orientation, the KBC emphasizes situated learning in a collaborative social environment where the learners struggle to solve authentic problems. This emphasis is common among reformed pedagogies that are labeled as constructivist (Kirschner, Martens, & Strijbos, 2004). Within this broad framework, interaction among members is the key mediator for the co-construction of shared perspectives and the appropriation of cognitive strategies employed by expert within the community.

Although the KBC model draws on the constructivist-oriented theories, researchers directly involved in developing KBC argued that the KBC has moved social-cultural framework beyond the acquisition of knowledge and appropriation of practices to that of creation of knowledge. For example, Scardamalia, Bereiter, and Lamon (1994) have criticized the current Vygotskian's view as overly focused on the internal cognitive structures of the learners while neglecting the social structures that facilitate knowledge advancement. The key element that distinguishes the KBC from the social-cultural framework is its emphasis on critical and creative work on ideas. This focus shifts the attention of a learning situation from internalization of existing practices and knowledge to the co-construction of new knowledge. Learning about the practice and knowledge becomes a by-product of being a knowledge worker. Despite the shift, the vital role of discourse in a KBC is not undermined because it is through discourse that knowledge or ideas are constructed, negotiated and improved (Lamon, Reeve, Scardamalia, 2001).

To direct the focus of discourse towards knowledge creation rather then knowledge telling in a KBC, learners are encouraged to produce cognitive artifacts such as explanations of phenomena they have encountered. These cognitive artifacts are then subjected to the community scrutiny for improvement. In practice, the knowledge building process is thus a process whereby participants create knowledge objects such as an explanation or a design document that represent their understanding. These knowledge objects are shared in the form of notes (i.e. an online message) through the KF™ platforms. The community then assumes the collective cognitive responsibilities to improve the objects through various activities such as gathering information through multiple sources; debating about the ideas and conducting empirical research (Scardamalia, 2002). Bereiter (1997) argued that engaging students in the improvement of knowledge object would lead students to the examination of existing theories, which would lead to learning. At the same time, the contexts created help the participants in learning about how to work with knowledge. Engaging learners in a KBC is in essence empowering learners to work constructively and creatively with ideas, i.e. to treat learners as knowledge producers (Bereiter, 2002).

The above review highlighted that the KBC model focuses on the co-construction and improvement of knowledge objects. Lipponen, Hakkarainen, and Paavola (2004) classified CSCL models that are similar to the KBC model within the knowledge creation framework, as contrasted with CSCL models that are founded on the acquisition framework or the participation framework of learning. Although differences in underlying framework usually lead to different practices and research foci, it seems reasonable to accept that participation and interactions are the enablers of learning and knowledge co-construction in CSCL environments. In other words, the success of a CSCL environments such as the KBC is under girded by participants' active participation in a socially acceptable and yet cognitively challenging manner. The recognition of the importance of the participation, social and cognitive dimensions are reflected in the analysis models that has been developed recently.

Analysis models of CSCL

Online interaction, as a form of discourse, is a complex and discursive phenomenon. Researchers in this field generally agree that mixed method multidimensional analysis is necessary to provide in-depth understanding (for example, Wegerif & Mercer, 1997; Hmelo-Silver, 2003). To date, several researchers had attempted to develop coding schemes to account for the different aspects of online interactions. One of the earlier attempts to analyze content is the model proposed by Henri (1992) that includes five dimensions and their categories as shown in Table 1.

Henri believed that her model would help educators to understand the learning processes that occur online comprehensively. Although the model is lacking in clear criteria and detailed descriptions (Howell-Richardson & Mellar, 1996), it is a useful tool in terms of laying the groundwork. Hara, Bonk and Angeli (2000) adapted the model for a study of 20 graduate students' online discussions. The results indicated that although students' participation was limited to one posting per week, the postings were cognitively deep. For the dimension on interactivity, they devised message maps that depicted students' interaction clearly. The study also revealed the difficulty in achieving high inter-rater reliability for the metacognitive dimension.

Table 1: Henri's (1992) Model of Content Analysis

Dimension	Categories
Participation	Levels of participation; Types of participation
Social	Statement or part of statement not related to subject matter
Interactivity	Explicit interaction: Direct response, Direct commentary Implicit interaction: Indirect response, Indirect commentary Independent statement
Cognitive Skills	Elementary clarification; In-depth clarification; Inference; Judgment; Application of strategies
Metacognitive Knowledge and Skills	Personal; Task; Strategies; Evaluation; Planning; Regulation; Self awareness

Another model proposed by Newman, Webb and Cochrane (1996) was designed to measure critical thinking (see Table 2). They used indicators of critical thinking through approximately 40 codes in categories such as relevance, justification, novelty, and ambiguities, each with a plus or minus appended to show whether the coded message contributes or detracts from critical thinking development (Marra, Moore & Klimczak, 2004).

Table 2: Newman, Webb and Cochrane's (1996) Model *

Category	Indicator
Relevance	Relevant states or diversions
Importance	Important points and issues or unimportant points and trivial issues
Novelty, new info, ideas, solutions	New problem related information or repeating what has been said
Bringing outside knowledge or experience to bear on problem	Drawing on personal experience or sticking to prejudice or assumptions
Ambiguities; clarified or confused	Clear statements or confused statements
Linking ideas, interpretation	Linking facts, ideas and notions or repeating information without making inferences or offering an interpretation
Justification	Providing proof or examples or irrelevant or obscuring questions or examples
Critical assessment	Critical assessment or evaluation of own or others' contribution or uncritical acceptance or unreasoned rejection
Practical utility (grounding)	Relate possible solutions to familiar situation or discuss in a vacuum
Width of understanding (complete picture)	Widen discussion or narrow discussion

* Adapted from Marra, Moore & Klimczak (2004)

Gunawradena, Lowe and Anderson (1997) developed an interaction analysis model (see Table 3) to examine meaning negotiation and co-construction of knowledge. The model describes co-construction of knowledge as five progressive phases. They are sharing, comparing of information; discovery of dissonance; negotiation of meaning/ co-construction of knowledge; testing and modification of proposed synthesis; agreement/ application of newly constructed meaning. Each phase consists of a number of operations such as stating an observation or asking questions. As it was developed in the context of a debate, how useful is the model in explicating the knowledge building processes that are not in the format of debate needs further research For example, it is not difficult to imagine a facilitator of an online discussion starting a knowledge building discourse by identifying an area of disagreement (Phase 2) or even with a negotiation of the meanings of terms (Phase 3). In such cases, the participants may move back to Phase 1 or proceed to the later phases.

Recent studies of online interactions roughly fall within the dimensions described above with adaptations to the specific contexts and purposes of the study. The common dimensions employed are participation, cognitive processing and social interactions. For example, Guzdial and Turns (2000) assessed over 1000 undergraduates used of online forum mainly from the participation dimension. Average number of postings, average length of threads, proportion of participants/ non-participants and on/off task notes were the indicators they employed to assess learning. Lipponen, Rahikainen, Lallimo and Hakkarainen (2003) categorised the students' postings of as on/off task, and further classified the functions of the postings as providing information, asking research/ clarification questions, and something else. They also measured the mean size of notes and the depth of notes and mapped out the social relations through case-by-case matrix. In the participation dimension, other than notes creation and responses/comments, they also made use of log files to study who-read-whose notes.

Table 3: Gunawardena, Lowe & Anderson's (1997) Interaction Analysis Model

	Phase	Operation
1	Sharing / comparing of information	Statement of observation or opinion; statement of agreement between participants
2	Discovery and exploration of dissonance or inconsistency among participants	Identifying areas of disagreement, asking and answering questions to clarify disagreement
3	Negotiation of meaning/co-construction of knowledge	Negotiating meaning of terms and negotiation of the relative weight to be used for various agreement
4	Testing and modification of proposed synthesis or co-construction	Testing the proposed new knowledge against existing cognitive schema, personal experience or other sources
5	Agreement statement(s)/application of newly constructed meaning	Summarizing agreement and metacognitive statements that show new knowledge construction

Schellens and Valcke's (2005) also employed similar dimensions. For the cognitive dimension, their scheme of classification is geared towards knowledge building rather than learning. They claimed that the scheme is parallel to Gunawardena et al.'s scheme. They have also differentiated between the use of theoretical and experiential information in the online messages for knowledge building. Analysis in this aspect is important, as one concern in CSCL is superficial exchange.

Background of the Study and Methodology

This study is a post-hoc analysis of the online interactions that were produced by a group of 11 in-service teachers and the tutor. The study is naturalistic in the sense that the researchers had no control over the selection of participants. They were teachers who had enrolled themselves in a program that leads to the award of Advanced Diploma in Information Technology. These teachers have diverse background in terms of the subjects and levels they taught. Years of service ranges from 2 to 33 years and 8 of them are primary and the remaining are secondary teachers. Their teaching subjects include Malay and Chinese languages, Design and technology, Computer applications, English, Mathematics, Science and Art.

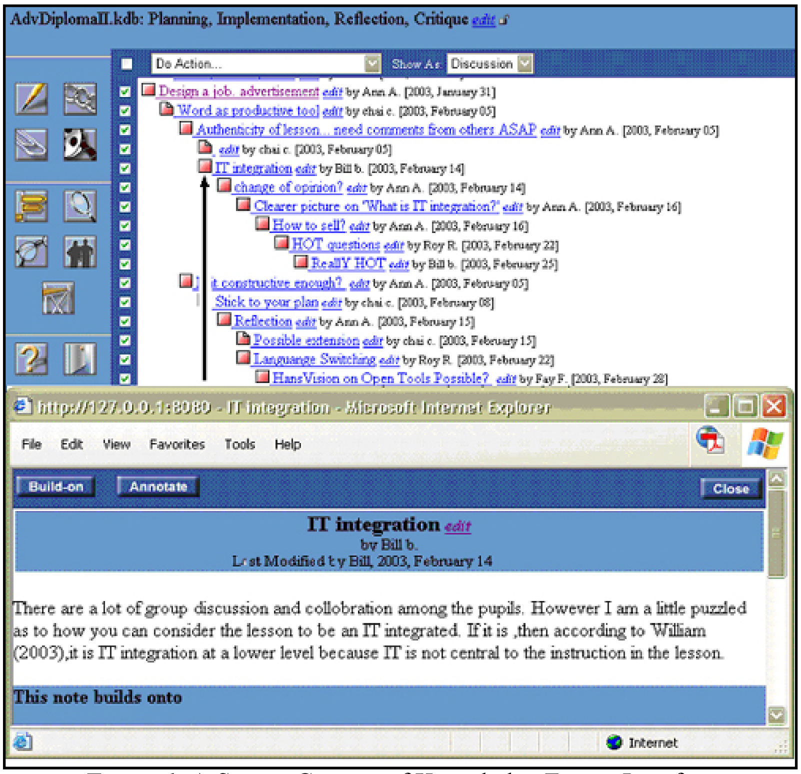

Figure 1: A Screen Capture of Knowledge Forum Interface

The in-service module was entitled "Integrating Information Technology into School Curriculum". The course was conducted from January to March 2003 and it lasted eight weeks. Half of the lessons were conducted face-to-face while the other half were online. At the beginning of the course, the KBC model was introduced to the participants. The learning activities can be roughly divided into three phases. In the first three weeks, teachers were tasked to discuss theoretical issues. Subsequently, they planned and implemented IT-based lessons for four weeks. All lesson plans and implementation records were shared through KF™. These were treated as data generated in practice for teachers to built-on each other's ideas and connect to their readings. In the last week, they wrote reflection notes about their experience of learning in a KBC and constructed mind-maps on the content learnt. The goal of the course was to allow teachers to construct collaboratively a comprehensive understanding about IT integration in classrooms. A brief example of how the researchers conceptualized the KBC for this study is given in the next paragraph.

Generally, within each phase, the teachers were encouraged to articulate their initial ideas and shared it through KF. These ideas were treated as cognitive artifacts created by the teachers based on their prior knowledge and they are subjected to peers' critiques for improvement. For example, Figure 1 shows a screen capture of a series of connected notes that were initiated by a teacher named Ann on the KF™ interface. The first note was a detailed lesson plan that Ann believed to be an IT integrated lesson. It tasked the students to interview a family member and create a job advertisement using the Word program. Treating the lesson plan as an improvable cognitive artifact, the instructor challenged Ann to improve on the authenticity of her lesson and commented that the use of Word did not appear to add value to students' learning. Another teacher, Bill, also raised questions on Ann's lesson plan as shown in the note at the lower half of figure 1. The challenges puzzled Ann and led her to reconsider what IT integration meant. For this instant, the puzzlement was resolved during the face-to-face session where Jonassen (2000) conceptualization of computers as mindtools was introduced by the instructor. Ann's final reflective note (see following quote), indicated that she had benefited from this process of knowledge co-construction.

> It (KBC) has helped me to understand better by reading and considering peoples' comments and ideas. Thus, resulting in a change and improvement of ideas. This can be seen clearly through the task on lesson planning. Ideas are drawn out at first. After comments and ideas, the task is developed better. (Ann)

Research Questions

The research question for this study is "how do teachers build knowledge collaboratively?" This is broken down into the following specific research questions:

1. What is the pattern of participation among the teachers?
2. What is the pattern of interaction among the teachers?
3. To what extent are the teachers building knowledge collaboratively?

Data Collection

Two main sources of data were collected for this study. They were the log files and the teachers' notes. The log files were generated by subjecting the database to the Analytic Toolkit® (Burtis, 1998) that analyses mainly the quantitative aspects of the knowledge building discourse. The files provide comprehensive quantitative indices that reveal the extent of knowledge-building activities (Chan & van Aalst, 2004). Reflective notes written by the researchers after the lessons supplemented the data.

Data Analysis

The data were analysed mainly through a combination of content analysis method as highlighted in the literature review. For this study, the participation, social and cognitive dimensions were chosen to provide a comprehensive answer to the research questions. Successful co-construction of knowledge requires active and broad participation. This implies that the messages posted should be substantial in term of quantity. It provides important background information against which the quality of interactions could be assessed. In the context of KBC that aims to promote deep understanding, the depth of discussion is crucial. The average length of threads was therefore computed. Analysis of the social dimension was conducted through computing the density of the social network. The Analytic Toolkit generated information on who interacted with whom in terms of both commenting/responding and reading of notes for this purpose. It will be presented in the form of a case-by-case matrix (Lipponen et al., 2003). Lastly, for the analysis of the cognitive dimension, Gunawardena's model was employed. The model was selected as it fits the purpose of this study and the underlying theoretical framework is compatible to the KBC. Notes that could not be classified within their model were given new codes and the model was modified slightly. Since notes that could be classified within Gunawardena's model were by default on task in nature, only notes that need new labels were examined for off task behaviour. The results were compared with results of other studies from different contexts. Although this comparison were loose in nature, it seemed that results obtained through different contexts exhibited some common problems about CSCL.

Results and Discussion

Participation Patterns

The numbers of notes created and the numbers of notes read were the two indicators selected for the examination of the extent of participation. Table 4 documents the data for these two areas. To provide a more comprehensive view, data about the number of words used was also obtained from the Analytic Toolkit® and the average number of words per note was calculated.

On average, the database grew by 25.6 notes per week with each teacher contributing about 2.33 notes in a week. The number of words written by each teacher in a week is about 300. The results suggest that the participation rate is relatively high although it is difficult to make accurate comparison with other studies because of the different contexts involved. Hara et al. (2000) reported an average of one note per week per postgraduate student with a length of about 300 words. Guzdial and Turns's (2000) study of undergraduate online interactions yielded a result of about one note for every two weeks. Schellen and Valcke (2005) reported coding of 1428 messages for analysis for 80 students studying "Instructional Sciences" in a time span of 12 weeks. The average was about 1.48 messages per week per student (a posting can be separated into several messages). No data was provided for the length of posting. Based on these comparisons, the in-service teachers in this study should be considered as active participants.

The facilitator (tutor) posted 45 notes with an average of 85.7 words per note. He contributed the highest number of notes that were coded to be of higher phases of knowledge construction. In Hara's study, the facilitator's average posting is twice (2.1 notes/ week) that of the students. For the present study, the facilitator posting is 2.4 times (5.63 notes) that of the teachers' postings. This result may indicate that active participation by the facilitator is crucial in developing and sustaining discussion among teachers. To verify this result, further search was performed on the database using the Analytic Toolkit®. 43 out of the 45 notes from the facilitator were responding to the teachers and it resulted in 38 responses from the teachers, accounting for 19% of the teachers' notes.

Table 4: Participation Patterns of the Teachers

Teacher	Total number of notes posted	Number of notes per week	Percentage of note read	Total number of words written	Average number of words per notes
Ann	29	3.6	96%	5268	181.7
Bill	21	2.6	36%	2006	95.5
Clare	26	3.3	38%	5143	197.8
Fay	16	2.0	31%	2398	149.9
Grace	19	2.4	42%	2748	144.6
Ivy	11	1.4	51%	618	56.2
Lynn	22	2.8	63%	3628	164.9
Nancy	12	1.5	50%	3124	260.3
Roy	22	2.8	83%	2743	124.7
Susan	14	1.8	20%	2566	183.3
Sam	13	1.6	16%	872	67.1

The average percentage of notes read for this study is 48%. This should be an encouraging result given that teachers are generally busy people who have to deal with multiple demands on their time. To examine the relationship between the writing and reading of notes, a correlation coefficient of 0.44 was obtained through computing the correlation the ranked order of teachers for writing and reading of notes. The result suggests that there is a moderate correlation between these two forms of participation. However, the result also suggests that obtaining information about participation in terms of reading notes could be important since writing of notes could only predict the reading of notes with an accuracy of approximately 20%.

Dividing the total number of notes by the total number of clusters yields the average length of threads. This study made used of explicit links of notes created through the built-on functions of KF™ by the teachers and did not examined the possible implicit links between the notes or the note clusters. There are 42 unconnected notes in the database and 30 clusters of connected notes. The unconnected notes are considered as a note cluster each, giving the total number of note clusters to be 72. There are 250 notes in total (including the facilitator's notes) the mean note cluster size for this study is 3.47. The result implies that for every note posted, it received two to three responses. This result suggests that the discussions are not adequately sustained (Lipponen et al., 2003).
Achieving sustained online interactions has been a perpetual problem that needs further examination. Hewitt (1996) reported a maximum of 5.6 notes/cluster result achieved by a teacher with doctoral degree after 4 years of experimenting KBC in an elementary classroom. Guzdial and Turns (2000), on the other hand, reported a maximum of 56.3 notes/cluster when the discussions were anchored around examinations and homework assignments. While the anchoring strategy may work for undergraduate, it is unlikely to work in the context of in-service teacher development.

Social Dimension of Participation

Table 5 and Table 6 below show the case-by-case matrix of "Who built-on whose" and "Who read whose" notes as generated by the Analytic Toolkit®. Reading off from the left to the right, the numbers shows how many times the teachers whose name appeared in the left column built-on or read the notes created by the teachers whose names appeared on the top row. For example, Ann had built-on to one of Bill's notes and three of Clare's notes. These tables provide information on who is/ is not interacting with whom, thereby allowing educators and researchers to have an overall understanding of how established the community is.

Based on the data in Table 5, the density of the network in term of participants building on each other's notes is computed using social network analysis. Scott (2000) defined social network density as "the extent to which all possible relations are actually present" (p. 32). The density is thus obtained by dividing the number of actual connections by the total number of possible connections. Since the computation is not directional, any connection that link two participants will be considered as an actual connection. Based on these premises, the density of Table 6 is computed to be 0.67. Lipponen et al. (2003) considered a density of 0.37 from his study as high. The density of the present study is therefore quite high.

Table 5: Who built-on whose notes?

	Ann	Bill	Clare	Fay	Grace	Ivy	Lynn	Nancy	Roy	Susan	Sam
Ann	--	1	3	0	1	0	3	2	1	0	0
Bill	1	--	1	1	1	2	0	0	1	0	3
Clare	2	0	--	0	0	0	4	0	2	1	0
Fay	2	0	0	--	1	0	2	1	2	1	0
Grace	2	0	1	1	--	0	2	1	2	1	0
Ivy	0	2	0	0	1	--	1	0	0	0	2
Lynn	3	0	3	1	1	0	--	0	0	0	0
Nancy	2	0	0	0	2	0	1	--	0	0	0
Roy	4	1	2	1	2	0	2	1	--	2	0
Susan	1	0	1	0	0	0	2	0	1	--	1
Sam	0	2	1	0	0	2	0	0	0	0	--

Table 6: Who read whose notes?

	Ann	Bill	Clare	Fay	Grace	Ivy	Lynn	Nancy	Roy	Susan	Sam
Ann	--	21	26	15	19	6	22	12	21	13	12
Bill	10	--	10	2	4	3	8	4	7	5	4
Clare	8	7	--	3	9	1	12	3	5	6	1
Fay	7	7	6	--	5	1	7	3	2	2	3
Grace	13	7	13	6	--	1	12	4	10	6	1
Ivy	13	13	13	6	9	--	9	8	10	4	6
Lynn	22	10	17	7	13	4	--	7	11	9	7
Nancy	13	10	9	7	12	1	10	--	9	7	5
Roy	29	13	23	11	18	2	21	11	--	8	7
Susan	5	2	3	1	4	0	4	2	7	--	4
Sam	2	7	5	2	1	1	2	1	1	3	--

Table 6 shows that the reading patterns of the participants are distributed in the sense that each participant read some notes from the rest of the participants. The only exception was Susan who did not read any note from Ivy. However, since Ivy read four of Susan's notes, a connection is still established. The social network density for reading is therefore a perfect 1.

Based on these findings, it seems that the teachers are well connected with each other, indicating that the community is fairly well established. This is a relatively conducive environment for collaborative knowledge building since the teachers are more likely to feel supported. There are three possible reasons for achieving this dense network. First, prior to this module, the teachers had attended another 8 weeks module and they therefore have a history of working together. Second, 50% of the course was conducted through face-to-face setting. The researchers observed that during break times, the teachers frequently shared their stories from their respective schools and talked about their problems. Informal sharing and having a shared history are both believed to be essential for fostering community (Kreijns, Kirschner, & Jochems, 2003). They help to establish trust among participants since they need to share and comment on each other personal knowledge, practices and beliefs. Third, the number of participants is small and this helps in promoting mutual connections (Lipponen, et al., 2003). It is also worth noting at this point that there were only two notes that were off task in the whole database. One note was requesting for sale information of certain IT product brought up during discussion and the other was an unfinished note. This shows that the teachers were highly task-oriented when they were interacting online. Given that 50% of the course was conducted through face-to-face setting, the highly task-oriented nature of the online interactions should not be surprising given the face-to-face sessions and the teachers shared history of working together.

Knowledge Building Dimension

Gunawardena's model of interaction analysis was applied for the coding of the online interactions. The steps of coding followed that suggested by Chi (1997). The codes were largely applicable to this study although there were times when the researchers have to make modified the code descriptions. For instance, the teachers shared their lesson plans and invited critiques from their peers. A lesson plan is in a sense a cognitive artifact that is derived and synthesized from the teacher's knowledge, beliefs and experience. It is a proposed synthesis (Phase 4) but it is not entirely a result of co-construction. The teachers constructed their lesson plans individually and they were shared as the first note for the initiation of idea refinement process. The researchers therefore decided that the notes should belong to Phase 1 and stage 1a. Following such decision, the code descriptions were modified. Only one additional code was created in Phase 3, i.e., proposing possible solutions for identified problems. It was placed in Phase 3 as defined by Gunawardena et al.(1997) as the phase in which idea co-construction occurs through proposals of ideas.

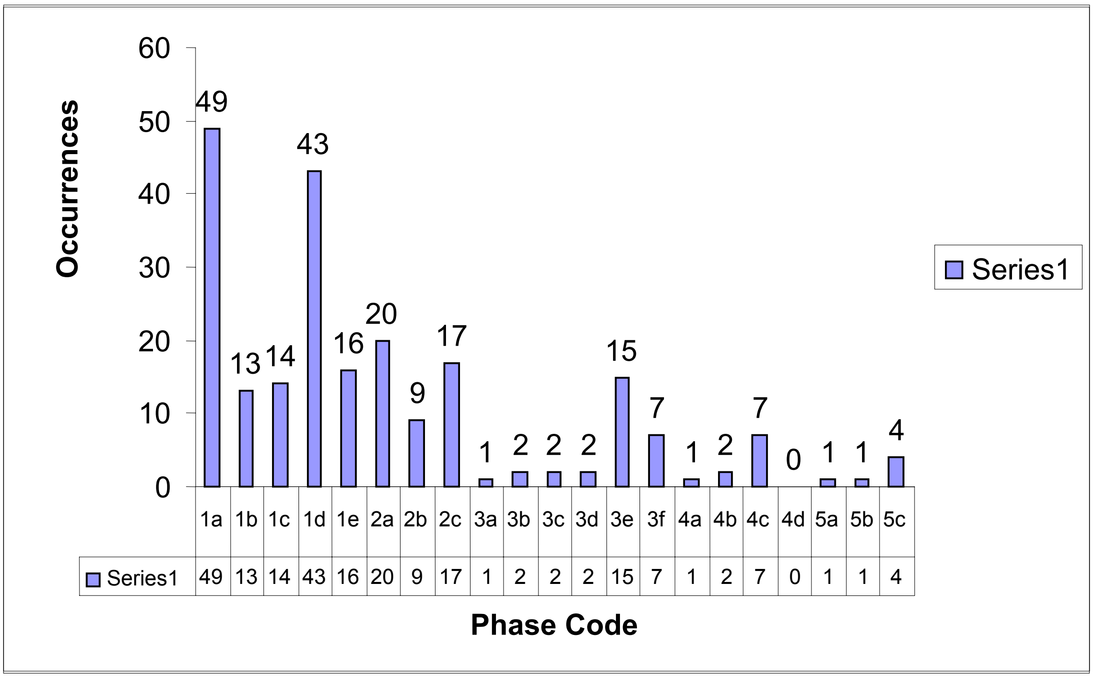

Figure2: Bar Chart of Occurrences Based on Coding Categories

The basic unit of analysis is a note. However, within a note, there were usually several paragraphs. For this study, the researchers did not go into segmenting the notes. Each note is examined for indications of presence of a phase and the results were recorded in a spreadsheet Notes that contain several paragraphs usually had more then one phases within it. The occurrences of the different phases were recorded but repeated occurrences of a phase were not treated as another occurrence within a note. The facilitator's notes were coded but not included for the computation in the following analysis because it would bias the results. During the course, the facilitator had consciously modeled the acts that would stimulate co-construction of knowledge.

The result of the coding is presented through a bar chart in Figure 2. Overall, there are a total of 226 coded incidents. Other then statements that are within Phase 1a, the rest of the codes represent some forms of co-

construction of knowledge. The proportion of Phase 1a occurrences (49) to the rest of the coded occurrences (179) is approximately 1:4. The result indicates that the teachers were able to built-on to each other's ideas. However, as illustrated by the bar chart and the pie chart in figure 3, most knowledge building activities were limited within Phase 1, i.e., sharing and comparing information. Within Phase 1, asking/ answering clarification questions and suggesting ideas for improvement occurred most often. However, the questions or ideas suggested did not challenge the fundamentals of the notes they were responding and thus did not result in further negotiation. Stahl (2002a) stated that in collaborating, people typically establish conventional dialogic patterns of proposing, questioning, augmenting, mutually completing, repairing, and confirming each other's expressions of knowledge.

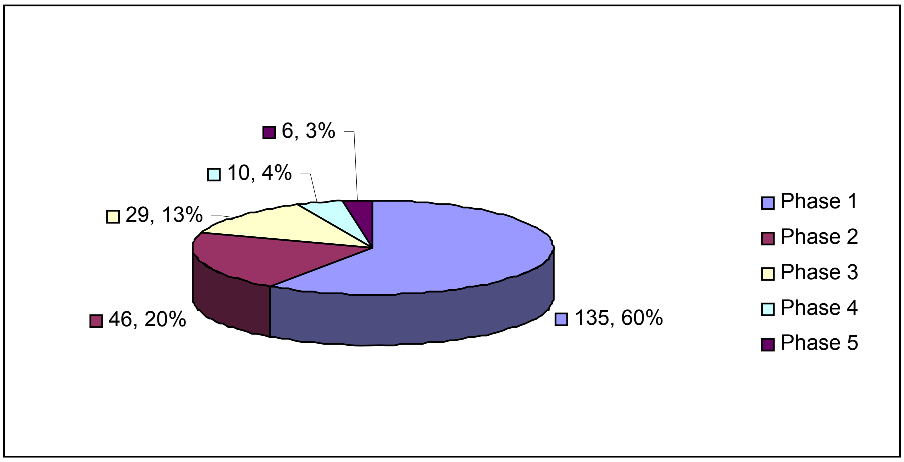

Figure 3: The Distribution of Knowledge Building Activities among the Five Phases

This is not an isolated phenomenon. Gunawardena et al.'s (1997) study obtained a result of 191; 5; 4; 2; 4 postings from Phase 1 to Phase 5 respectively. Her participants were practitioners of online education or graduate students. Schellens and Vackle (2005) used Gunawardena's model to analyze undergraduates' online postings and found 52%; 14%; 33%, 1.2% and 0.4 % from Phase 1 to Phase 5 respectively. The results seem to indicate that higher phases of co-construction of knowledge are difficult to achieve. Reviews of studies on teacher networked-based learning had also yielded similar results (see Zhao & Rop, 2001). While the technological affordances of networked environment seems to provide an avenue for collaborative learning, there seems to be a higher possibility for the participants to share information and perhaps request for elementary clarification. These results also seem to corroborate with the quantitative results obtained by most studies (and this study) in terms of the average thread length. It seems reasonable to assume that high level of knowledge construction did not happen when the typical structure of a forum is one first level note followed by two to three responses.

There are several possible reasons that could account for the results obtain is this study. First, detecting dissonance and building on ideas is a cognitively demanding task. It requires the teachers to think through the emerging issues and construct appropriate responses based on relevant experiences and literature. The multiple demands they had to answer to in their work life placed severe time constraint on their learning (Yamagata-Lynch, 2003). This study was conducted in a blended environment where the teachers were working full time without any offloading from school. A related study on teachers' perception of learning in this environment suggested that time constraint is a real issue for the teachers (Chai, Tan & Hung, 2003).

Second, criticizing each others' practices maybe culturally not an appropriate behaviour since it may be perceived as confrontational. The cultural norms of niceness among teachers may have discouraged the teachers from engaging in critical discussion (Lampert & Ball, 1999). Unless the participants have established trusting relation and are confident that they have indeed detected consistency or a gap in understanding, they are not likely to voice confrontational opinion. The researchers were enlightened to this by one of the participating teacher's remark that unless she was sure about what she had to say, she would not comment on others' classroom practices. She did not feel comfortable doing that because she did not know the students and was not responsible for what happen to the class. Her remarks had not only illustrated the cultural norms of respecting others but also highlighted the important but not easily accessible knowledge about students that teachers need to have in order to comment on practice.

Third, teachers' friendship and collegiality may work in a way that instead of providing a trusting relationship for critical dialogue, it reduces teachers' willingness to engage in activities that could be questioning the validity of certain beliefs (Kelchtermans, 2004). In other words, teachers may treasure their collegiality more than the opportunities to create knowledge together.

Fourth, teachers were traditionally treated as implementers of education decisions made outside the classrooms. The shift of role from knowledge consumer to that of knowledge producer is not an easy one as most graduate students may testify. Much training and knowledge acquisition are needed. This study examined only the eight weeks of teachers interaction. It would be interesting to examine the teachers' interactions in more extended timeframe. Lastly, it is important to note that although the level of knowledge-building as measured using Gunawardena's scheme does not seem to be high, the course evaluation and studies from teachers' perspectives indicated that the teachers were very satisfied with their learning (Chai et al., 2003).

The results of this study have helped us to understand the complexity of knowledge co-construction in CSCL environments in more details and point to the needs of exploring strategies that would promote participants' ability and willingness to challenge each other's assumptions. In the concluding sections, we will dwell further on the implications of this study towards practice and research.

Summary

This study examined the pattern of participation and discourse analysis of the online interaction among the online interactions of a group of 11 teachers in the context of professional development. The results indicated that the community established through the combination of face-to-face and online interactions was rather cohesive. The teachers' participation in the online environment in terms of both reading and responding to each other's notes was also relatively high and their interactions were task-focused. Based on the results obtained, it seems fair to conclude that the teachers had managed to appropriate some practices of the KBC. However, the depth of interaction was still lacking even when the social conditions exist.

The results of this study suggests that cohesiveness at the level of distributed reading and built-on is a necessary but insufficient condition for in-depth knowledge building. For in-depth knowledge building discourse to happen within the context of teacher professional development, the teachers need to challenge the cultural/professional norm of niceness; be able to detect gaps in understanding; have adequate knowledge about the context of another teacher's classroom; have the necessary social skills in putting across the critical comments; and assumes a new identity of knowledge producer. None of these seem easy to achieve and all seem necessary. This implies although it is now technologically possible to provide ample opportunities for learners to participate in educational activities, educators have to carefully engineer the social, cultural, cognitive dimensions of the learning environment before they can reap the benefits afforded by technologies. In other words, the degree to which CSCL can enhance learning depends on how skillful the facilitator is. There also seem to be no prescription available on how to form the desired learning environment. It seems that teacher educators or the online facilitators need to constantly model the skills through written responses. Reiman's (1999) taxonomy of guided written reflections could serve as a good model. He emphasized on the techniques of matching and gradual mismatching for the creation of zone of proximal reflection. Presumably, when a participant has received enough exposure of being guided for knowledge construction, he/she may appropriate the practice. This further implies that courses employing the KBC or similar model need to stretch over a longer period of time for the critical and creative discourse practice to be appropriated by the learners.

Time is an important factor for knowledge building discourse to be shaped. Lack of time has been cited as a key factor that hindered reflective discourse from occurring in online environment (Zhao & Rop, 2001). There is no existing guideline or heuristic on how much time is required. It seems to be dependent on the historical, social and cultural context of the group of learners in the community. A group of learners who come from a discipline background where critical and creative discourse is valued could start the knowledge building discourse instantly once basic social cohesiveness is established. In the Singapore context and for teachers who are used to working in isolation, the researchers' intuitive assessment would be at least six months. However, few courses in higher education are beyond 15 weeks. The fragmented nature of professional development activities is ill-suited for the purpose of achieving deep understanding that is constituted through progressive discourse (Ball & Cohen, 1999). One way to beat the system is to employ a single pedagogical approach for several courses that cover different subject matter. This is the next step where the present researchers of this study are heading. As for research method in specific, one possible way to gain deeper understanding is to perform finer grain discourse analysis or microgenetic analysis of the online discourse (Stahl, 2004). The online discourse could be interpreted with reference to the course structures and the facilitator's forms of participation to tease out possible strategies to promote higher level of knowledge co-construction.

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Learning Portfolio Analysis and Mining for SCORM Compliant Environment

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ABSTRACT

With vigorous development of the Internet, e-learning system has become more and more popular. Sharable Content Object Reference Model (SCORM) 2004 provides the Sequencing and Navigation (SN) Specification to define the course sequencing behavior, control the sequencing, selecting and delivering of course, and organize the content into a hierarchical structure, namely Activity Tree. Therefore, how to provide customized course according to individual learning characteristics and capabilities, and how to create, represent and maintain the activity tree with appropriate associated sequencing definition for different learners become two important issues. However, it is almost impossible to design personalized learning activities trees for each learner manually. The information of learning behavior, called learning portfolio, can help teacher understand the reason why a learner got high or low grade. Thus, in this paper, we propose a Learning Portfolio Mining (LPM) Approach including four phases: 1. User Model Definition Phase: define the learner profile based upon existing articles and pedagogical theory. 2. Learning Pattern Extraction Phase: apply sequential pattern mining technique to extract the maximal frequent learning patterns from the learning sequence, transform original learning sequence into a bit vector, and then use distance based clustering approach to group learners with good learning performance into several clusters. 3. Decision Tree Construction Phase: use two third of the learner profiles with corresponding cluster labels as training data to create a decision tree, and the remainings are the testing data. 4. Activity Tree Generation Phase: use each created cluster including several learning patterns as sequencing rules to generate personalized activity tree with associated sequencing rules of SN. Finally, for evaluating our proposed approach of learning portfolio analysis, an experiment has been done and the results show that generated personalized activity trees with sequencing rules are workable and beneficial for learners.

Keywords

Learning portfolio analysis, SCORM, Data mining, Personalized learning environment

Introduction

With vigorous development of the Internet, e-learning system has become more and more popular. Sharable Content Object Reference Model (SCORM, 2004), the most popular standard for the consistency of course format among different e-learning systems, provides the Sequencing and Navigation (SN) specification (SN, 2004), which relies on the concept of learning activities, to define the course sequencing behavior, control the sequencing, selecting and delivering of course, and organize the content into a hierarchical structure, namely Activity Tree (AT) as a learning map.

Therefore, how to provide customized course according to individual learning characteristics and capabilities, and how to create, represent and maintain the activity tree with appropriate associated sequencing definition for different learners become two important issues. However, it is almost impossible to design personalized learning activities trees for each learner manually. The information of learning behavior, called learning portfolio, including learning path, preferred learning course, grade of course, and learning time, etc., can help teacher understand the reason why a learner got high or low grade. Thus, in this paper, we apply data mining approaches to extract learning features from learning portfolio based on the predefined data format and then adaptively construct personalized activity trees with associated sequencing rules for learners.

Our approach includes the following four phases: 1. User Model Definition Phase: we define firstly the learner profile including gender, learning style, and learning experience, etc., based upon existing articles and pedagogical theory. 2. Learning Pattern Extraction Phase: we apply sequential pattern mining technique to extract the maximal frequent learning patterns from the learning sequence within learning portfolio. Thus, original learning sequence of a learner can be mapped into a bit vector where the value of each bit is set as 1 if the corresponding learning pattern is contained, and distance based clustering approach, e.g., K-means, can be used to group learners with good learning performance into several clusters. 3. Decision Tree Construction Phase: after extraction phase, every created cluster will be tagged with a cluster label. Thus, two third of the learner profiles with corresponding cluster labels are used as training data to create a decision tree, and the remainings are the testing data. 4. Activity Tree Generation Phase: finally, each created cluster including several learning patterns as sequencing rules can be used to generate personalized activity tree with associated sequencing rules of SN.

Therefore, via the personal learning characteristics acquired by questionnaire, a new learner can be classified into one specific cluster based upon the decision tree and a personalized activity tree adaptively created for this cluster will be provided for achieving the good learning results expectably.

Related Work

In this section, we review SCORM standard and some related works as follows.

SCORM (Sharable Content Object Reference Model)

Among those existing standards for learning contents, SCORM (2004) is currently the most popular one. It is a product of the U.S. Government's initiative in Advanced Distributed Learning (ADL). In November of 1997, the Department of Defense and the White House Office of Science and Technology Policy launched the ADL initiative with the goal of providing access to high-quality education and training materials that are easily tailored to individual learner needs and available whenever and wherever they are needed. SCORM-compliant courses leverage course development investments by ensuring that compliant courses are *Reusable*, *Accessible*, *Interoperable*, and *Durable*. Moreover, the Sequencing and Navigation (SN) in SCORM 1.3 (aka SCORM 2004), relies on the concept of learning activities. Content in SN is organized into a hierarchical structure, namely Activity Tree (AT) as a learning map. The example of AT is shown in Figure 1. Each activity including one or more child activities has an associated set of sequencing behaviors, defined by the Sequencing Definition Model (SDM) which is a set of attributes used by SN. For example, the root activity A includes three child activities, AA, AB, and AC. The SN process uses information about the desired sequencing behavior to control the sequencing, selecting and delivering of activities to the learner. The intended sequence is described by a specific set of data attributes, which are associated with learning activities in the activity tree to describe the sequencing behavior.

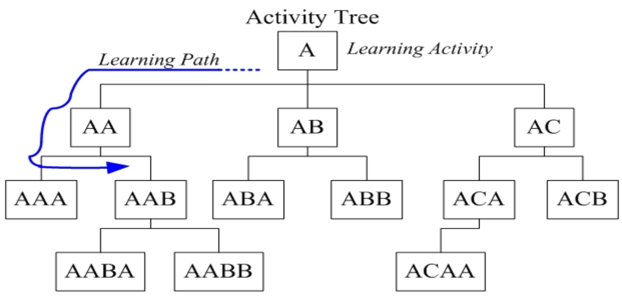

Figure1. An example of activity tree

The sequencing behaviors describe how the activity or how the children of the activity are used to create the desired learning experience. SN makes no requirements on the structure, organization or instruction of the activity tree. The tree and the associated sequencing definitions may be static or dynamically created. Therefore, how to create, represent and maintain the activity tree and associated sequencing definition, which is not specified, is an important issue. SN enables us to share not only learning contents, but also intended learning experiences. It provides a set of widely used sequencing method so that the teacher could do the sequencing efficiently.

Other Related Research

In adaptive learning environment, Shang et al. (2001) proposed an intelligent environment for active learning to support the student-centered, self-paced, and highly interactive learning approach. The learning environment can use the related learning profile of student, e.g., learning style and background knowledge, to select, organize, and present the customized learning materials for students. Trantafillou et al. (2003) also proposed an adaptive learning system, called AHS, in which Learners can be divided into two groups with Field Independence (FI) and Field Dependence (FD) respectively according to their cognitive styles. Then, the AHS system can provide appropriate strategy and learning materials for different groups. Moreover, according to learning styles and learning experience of learners, Gilbert et al. (1999) applied the Case Based Reasoning (CBR) technique to assign a new learner to the most similar one of four groups. Based upon the learning experience in group selected by CBR, the proposed system can offer the new learner an adaptive learning material. However, in all systems mentioned above, the information and approaches used to represent and group learners respectively are too easy to provide learners with personalized learning materials.

In addition, for learning portfolio analysis, Chen et al. (2000; Chang et al., 1998) applied decision tree and data cube techniques to analyze the learning behaviors of students and discover the pedagogical rules on students' learning performance from web logs including the amount of reading article, posting article, asking question, login, and etc. According to their proposed approach, teachers can easily observe learning processes and analyze the learning behaviors of students for pedagogical needs. However, although their proposed approaches can observe and analyze the learning behavior of students, they don't apply education theory to model the learning characteristics of learners. Therefore, the learning guidance can not be provided automatically for the new learner. For providing the personalized recommendation from historical browser behavior in e-learning system, Wang and Shao (2004) proposed a personalized recommendation approach which integrates user clustering and association-mining techniques. Based upon a specific time interval, they divided the historical navigation sessions of each user into frames of sessions. Then, a new clustering method, called HBM (Hierarchical Bisecting Medoids Algorithm) was proposed to cluster users according to the time-framed navigation sessions. In the same group, the association-mining technique was used to analyze those navigation sessions for establishing a recommendation model. Thus, this system can offer the similar students personalized recommendations. However, in this approach, the learning characteristics and sequential learning sequence of students were not considered, so that the personalized recommendation may be not appropriate. Of course, it doesn't support SCORM 2004 standard yet.

Learning Portfolio Analysis Using Data Mining Approach

Several articles (Beekhoven et al., 2003; Fayyad, 1997; Kolb, 1976; Smith & Tillema, 1998; Wang & Shao, 2004) have proposed that a new learner will get the similar learning performance if providing the learning guidance extracted from previous similar learners. The concept is the same as the adage of Chinese, "Good companions have good influence while bad ones have bad influence." Therefore, we conclude that a new learner could get the high learning performance if s/he follows the effective learning experience of similar learners. However, this conclusion results in the following three issues should be solved: (1) how to acquire the learning characteristics of learners, (2) how to group learners into several groups according to her/his individual learning characteristics, and (3) how to assign a new learner to a suitable group for offering her/him personalized learning materials.

The Process of Learning Portfolio

During learning activity, learning behaviors of learners can be recorded in database, called *learning portfolio*, including learning path, preferred learning course, grade of course, and learning time, etc., in e-learning environment. Articles (Agrawal & Srikant, 1995; Chang et al., 1998; Dewhurst et al., 2000; Smith, 2001; Quinlan, 1986; Shashaani & Khalili, 2001) have proved that the information of learning portfolio can help teacher analyze the learning behaviors of learners and discover the learning rules for understanding the reason why a learner got high or low grade.

Therefore, based upon the learning portfolio with the predefined data format, we can apply sequential pattern mining approach to extract frequent learning patterns of learners. Then, according to these mined learning patterns, these learners can be grouped into several groups with the similar learning behaviors using clustering approach. By using the questionnaires including the Learning Style Indicator (LSI, 2004), Group Embedded

Figures Test (GEFT) (Witkin et al., 1971), etc. to acquire the learning characteristics of learners, we can acquire the learning characteristics of learners as learner profile which can be used to create a decision tree to predict which group a new learner belongs to.

Thus, in this paper, we propose a four phase Learning Portfolio Mining (LPM) Approach using sequential pattern mining, clustering approach, and decision tree creation sequentially. Then, in the last Phase, we also propose an algorithm to create personalized activity tree which can be used in SCORM compliant learning environment.

The Framework of Learning Portfolio Mining (LPM)

As mentioned above, we propose a Learning Portfolio Mining (LPM) approach to extract learning features from learning portfolio and then adaptively construct personalized activity tree with associated sequencing rules for learners.

As shown in Figure 2, the LPM includes four phases described as follows:

1. User Model Definition Phase: we define firstly the learner profile including gender, learning style, and learning experience, etc. based upon existing articles and pedagogical theory, and the definitions of what we are going to discover in database.
2. Learning Pattern Extraction Phase: we apply sequential pattern mining technique to extract the maximal frequent learning patterns from the learning sequence within learning portfolio. Thus, original learning sequence of a learner can be mapped into a bit vector where the value of each bit is set as 1 if the corresponding learning pattern is contained, and distance based clustering approach can be used to group learners with good learning performance into several clusters.
3. Decision Tree Construction Phase: after extraction phase, every created cluster will be tagged with a cluster labels. Thus, two third of the learner profiles with corresponding cluster label are used as training data to create a decision tree, and the remainings are the testing data which can be used to evaluate the created decision tree.
4. Activity Tree Generation Phase: finally, each created cluster including several learning patterns as sequencing rules can be used to generate personalized activity tree with associated sequencing rules of Sequencing and Navigation (SN).

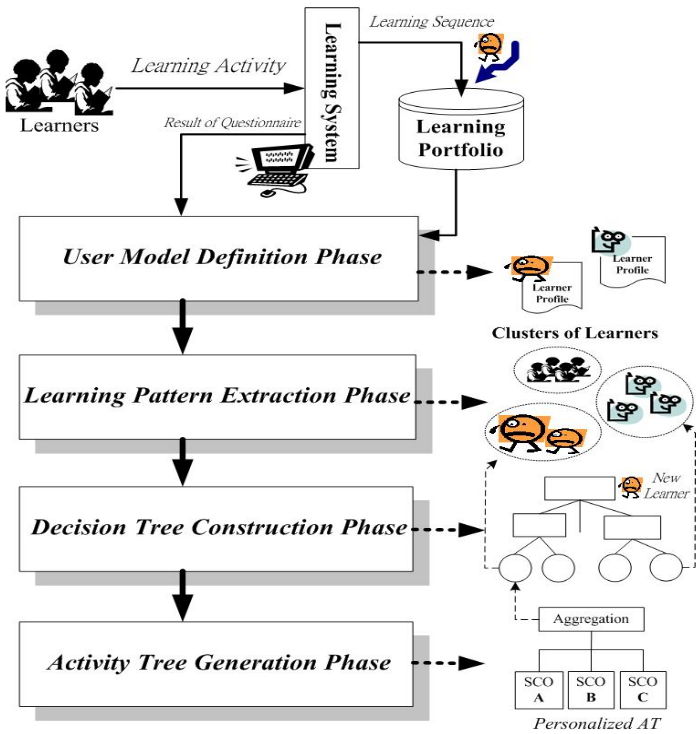

Figure 2. The flowchart of LPM

The details of each phase will be described in the following sections.

The Clustering Process of Learner

In this section, we will describe the User Model Definition Phase and Learning Pattern Extraction Phase in LPM.

User Model Definition Phase

Before extracting the learning features, we have to define a user model as learner profile, which will be recorded in database, to represent every learner. The definition is described as follows:

Learner L= (*ID*, *LC*, *LS*), where

- ***ID*:** denotes the unique identification of a learner.
- ***LC*** **=** <$c_1c_2\ldots c_n$>**:** denotes the sequence of learning characteristics of a learner.
- ***LS*** **=** <$s_1s_2\ldots s_n$>**:** denotes the learning sequence of a learner during learning activity, where s_i is an item of learning content.

In this paper, how to efficiently apply the existing pedagogical theories and how to further propose an efficient approach to solve personalized learning problem are our main concerns. Therefore, we only survey several related articles (Kolb, 2004; Beekhoven et al., 2003; Chen & Mizoguchi, 1999; Dewhurst et al., 2000; Smith, 2001; Gilbert & Han, 1999; Kolb, 1976; McIlroy et al., 2001; Riding & Cheema, 1991; Shashaani & Khalili, 2001; Wilson, 2000; Witkin et al., 1971), which investigated about 1) Learner Model, 2) Learning Style and Motivation, 3) course module category, 4) Learning Style, 5) Cognitive Styles, 6) Gender Difference, and 7) Student Characteristics, and then define the frequent learning characteristics for representing a learner by integrate their proposed leaning characteristics. The defined user model can also be extended if necessary. As shown in Table 1, the values of *Gender*, *Age*, *Education Status*, *Computer Experience*, and *Media Preference* can be inputted by learners directly and the values of *Learning Motivation*, *Cognitive Style*, *Learning Style*, and *Social Status* can be acquired by questionnaire, where we use the Learning Style Indicator (LSI, 2004) and Group Embedded Figures Test (GEFT) (Witkin et al., 1971) to acquire the Kolb's Learning Style (Kolb, 2004) and the information about field dependence/independence in Cognitive style, respectively. Here, the numeric value of *Age* can be transformed into symbolic with {L, M, H}. The transformation principle is described as follows:

In all learners, ℓ and μ are the minimal and maximal values of age, respectively. Let $\Delta=(\ell - \mu)/3$, and then a numeric value of age can be mapped into symbolic value with **L** in $[\ell, \ell+\Delta)$, **M** in $[\ell+\Delta, \ell+2\Delta)$, and **H** in $[\ell+2\Delta, \ell+3\Delta]$.

For example, **LC** = <F, M, S Y, H, FD, D, T, H> denotes that a learner is a *Female*, Age is *Medium* among all learners, Education Status is *Senior*, and etc. Nevertheless, the learning characteristics in user model can be modified for the real needs. In addition, the **LS** denotes a learning sequence of a learner. For example, in Figure 1, **LS** = <A, AA, AAA, AAB, AB> denotes that a learner studies the learning content A first and then studies the learning content AB. Therefore, based upon the user model, the learner can be represented as **L**=(35, <F, M, S Y, H, FD, D, T, H>, < A, AA, AAA, AAB, AB>).

Table 1. The learning characteristics of learner

Attribute	Value
Gender	**F:** *Female*, **M:** *Men*
Age	**L:** $[\ell, \ell+\Delta)$, **M:** $[\ell+\Delta, \ell+2\Delta)$, **H:** $[\ell+2\Delta, \ell+3\Delta]$
Education Status	**E:** *Elementary*, **J:** *Junior,* **S:** *Senior*, **U:** *Undergraduate,* **G:** *Graduate*
Computer Experience	**Y:** *Yes*, **N:** *No*
Learning Motivation	**L:** *Low*, **M:** *Medium*, **H:** *High*
Cognitive Style	**FD:** *Field Dependence,* **FI:** *Field Independence*
Learning Style	**D: Doer (***Concrete Experience & Active Experimentation*) **W: Watcher** (*Reflective Observation & Concrete Experience*) **T: Thinker (***Abstract Conceptualization & Reflective Observation*) **F: Feeler** (*Active Experience & Abstract Conceptualization*)
Media Preference	**A:** *Audio*, **V:** *Video*, **T:** *Text*, **P:** *Picture*, **M:** *Picture & Text*
Social Status	**L:** *Low*, **M:** *Medium*, **H:** *High*

Learning Pattern Extraction Phase

After defining the user model, we can apply sequential pattern mining technique to extract the maximal frequent learning patterns from the learning sequence within learning portfolio. Because we want to provide the new learner with effective learning guidance, we collect the learning sequences of learners with high learning performance, e.g., testing grade, from database, as shown in Table 2. For extracting the frequent learning pattern, the *Learning Pattern Extraction Phase* includes three processes shown in Figure 3: (1) Sequential Pattern Mining Process, (2) Feature Transforming Process, and (3) Learner Clustering Process.

Table 2. The learning sequences of 10 learners

ID	Learning Sequence (LS)
1	<B, C, A, D, E, F, G, H, I, J>
2	<A, B, H, D, E, F, C, G, I, J>
3	<A, D, F, G, H, B, C, I, J>
4	<A, B, D, E, C, F, G, H>
5	<A, C, J, F, B, H, D, E, I, G>
6	<B, H, F, D, E, A, G, C, I>
7	<A, J, E, H, B, C, I, D, G>
8	<B, C, G, E, A, H, D, I, J, F>
9	<C, E, G, F, J, B, H, A, D>
10	<B, C, A, J, D, E, G, H, F, I>

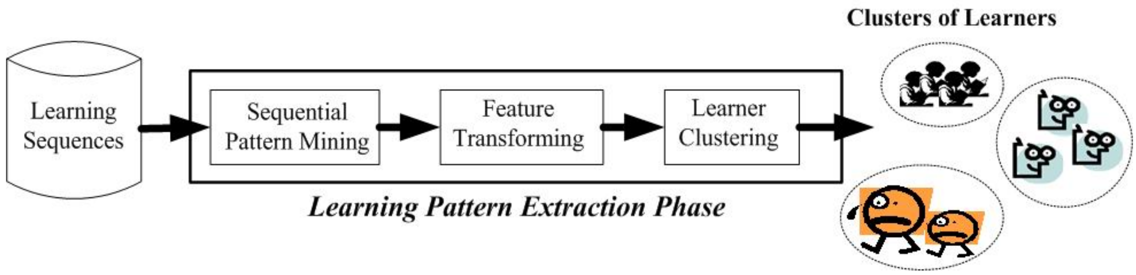

Figure 3. Learning Pattern Extraction Phase

Sequential Pattern Mining Process

In this paper, we modify a sequential pattern mining approach, called GSP algorithm (Agrawal & Srikant, 1995; Srikant & Aggrawal, 1996), to extract the frequent learning patterns from learning portfolio because we use the maximal frequent learning pattern to represent the learning features of learners, shown in Figure 4.

Algorithm: Modified GSP Algorithm

Symbol Definition:
α: The minimum support threshold.
C_ℓ : The ℓ -Candidate itemset.
L_ℓ : The ℓ -large itemset
support(x) : it estimates the number of *x* in C_ℓ .
Input: Learning Sequence(*LS*) of learner, Minimal Support (α)
Output: The set of maximal frequent learning patterns (***MF***).
Step1: Generate and insert the 1-itemset into C_1
Step2: L_1={x |support(x)≥α, for x∈ C_1}
Step3: Repeatedly execute this step until C_ℓ = *NULL*.
3.1: $C_\ell = L_{\ell-1}$ JOIN $L_{\ell-1}$
3.2: L_ℓ ={*x* |support(*x*)≥α, for *x*∈ C_ℓ }
3.3: Insert x∈ L_ℓ into ***MF***, if ∃ subsequence $y \subset x$ in ***MF*** then delete it.
Step5: output the ***MF***

Figure 4. Maximal frequent sequential pattern mining algorithm

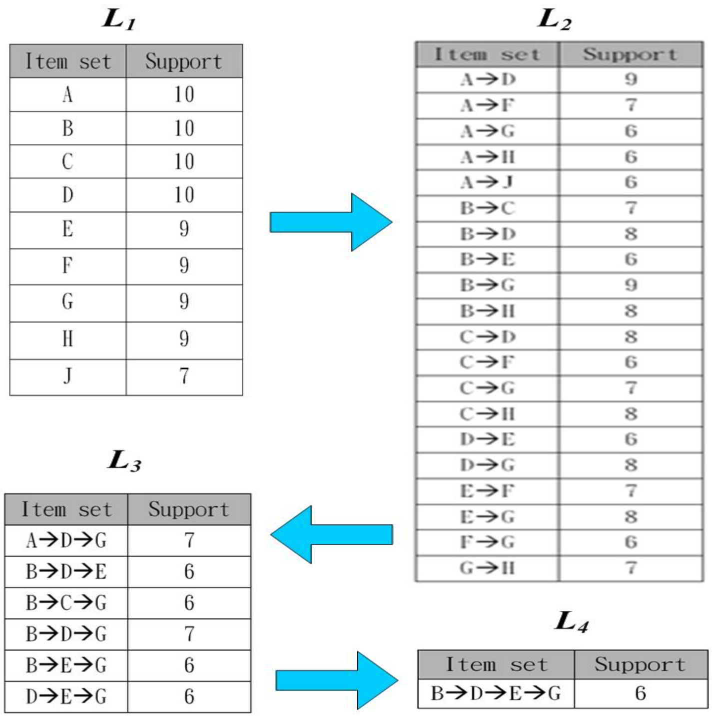

Figure 5. Mining process of modified GSP algorithm with $\alpha = 6$

In Figure 4, the subsequence definition and JOIN process **(Step 3.1)** which are borrowed from GSP algorithm are described as follows. A sequence s_1 joins with s_2 if the subsequence obtained by dropping the first item of s_1 is the same as the subsequence obtained by dropping the last item of s_2. The candidate sequence generated by joining s_1 with s_2 is the sequence s_1 extended with the last item of s_2. For example, in L_3, sequence <A, B, C> joins with <B, C, D> to generate <A, B, C, D> for generating the C_4. In addition, in **MF**, a subsequence <A, B> and <B, C> will be deleted if a sequence <A, B, C> is generated in L_3 and <A, B, C> is the maximal frequent learning patterns (**Step 3.3**). Figure 5 shows the mining process of Modified GSP Algorithm with minimal support threshold α=6. Therefore, after applying the Modified GSP Algorithm for the learning sequences in Table 2, we can get the maximal frequent learning patterns as shown in Table 3.

Table 3. The set of maximal frequent learning patterns (MF)

Large Itemset	**Maximal Frequent Learning Patterns**									
L_2	A→F	A→H	A→J	B→H	C→D	C→F	C→H	E→F	F→G	G→H
L_3	A→D→G	B→C→G								
L_4	B→D→E→G									

Feature Transforming Process

The generated maximal frequent learning patterns can be used to represent learning features of learners, which denotes that a learner would get high learning performance if s/he follows these learning patterns. Thus, based upon maximal learning patterns in Table 3, the original learning sequences of every learner can be mapped into a bit vector where the value of each bit is set as 1 if the mined maximal learning pattern is a subsequence of original learning sequence. For example, in Table 3, the frequent learning pattern <B→D→E→G> is a subsequence of learning sequence <A, B, H, D, E, F, C, G, I, J> of second learner and the <C→D> is not. Therefore, we can get the bit vector of every learner according to feature transforming process (Guralnik & Karypis, 2001) as shown in Table 4.

Table 4. The result of feature transforming process

TID	B→D→E→G	A→D→G	B→C→G	A→F	A→H	A→J	B→H	C→D	C→F	C→H	E→F	F→G	G→H
1	1	1	1	1	1	1	1	1	1	1	1	1	1

2	1	1	1	1	1	1	1	0	0	0	1	1	0
3	0	1	0	1	1	1	0	0	0	0	0	1	1
4	1	1	1	1	1	0	1	0	1	1	1	1	1
5	1	1	0	1	1	1	1	1	1	1	0	1	0
6	1	0	0	0	0	0	1	0	0	0	0	1	0
7	0	1	1	0	1	1	0	1	0	0	0	0	0
8	0	0	1	1	1	1	1	1	1	1	1	0	1
9	0	0	0	0	0	0	1	1	1	1	1	0	1
10	1	1	1	1	1	1	1	1	1	1	1	0	1

Learner Clustering Process

As mentioned above, every learner can be represented by mined frequent patterns. Therefore, we can apply clustering algorithm to group learners into several clusters according to learning features of learners. In the same cluster, every learner with high learning performance has the similar learning behaviors. However, it is difficult to determine the number of clusters for applying clustering approach like K-means algorithm. A clustering algorithm, called ISODATA (Hall & Ball, 1965), can dynamically change the number of clusters by lumping and splitting procedures and iteratively change the number of clusters for better result. Therefore, in this paper, we apply the ISODATA clustering approach to group learners into different clusters. The Table 5 shows the result after applying ISODATA Clustering Algorithm for Table 4. The bit vector in Cluster Centroid Field denotes the representative learning patterns set in a cluster, which will be used to generate the sequencing rules of SCORM later.

Table 5. The result of applying ISODATA clustering algorithm

Cluster Label	ID of Learner	Cluster Centroids
1	{1, 4, 5, 8, 10}	<1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1>
2	{7}	<0, 1, 1, 0, 1, 1, 0, 1, 0, 0, 0, 0, 0>
3	{2, 3, 9}	<1, 1, 0, 1, 1, 1, 0, 0, 0, 0, 0, 1, 0>
4	{6}	<1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 0, 1, 0>

The Prediction and Construction of Learning Guidance

In this section, we will describe the Decision Tree Construction Phase and Activity Tree Generation Phase in LPM.

Decision Tree Construction Phase

After learner pattern extraction phase, every created cluster will be tagged with a cluster label as shown in Table 5. However, how to assign a new learner to a suitable cluster according to her/his learning characteristics and capabilities is an issue to be solved. Fortunately, the decision tree approach can solve this issue. Thus, based upon the Learner Profiles with cluster labels in Table 6, we can apply decision tree induction algorithm, ID3 (Quinlan, 1986), to create a decision tree. In this paper, two third of the learner profiles with associated cluster label are used as training data to create a decision tree, and the remainings are the testing data. The result of applying ID3 algorithm is shown in Figure 6.

Table 6. The learner profiles with cluster labels

ID	Gender	Age	Education Status	Computer Experience	Learning Motivation	Cognitive Style	Learning Style	Preferred Media	Social Status	Cluster Label
1	F	M	U	Y	M	FI	D	A	H	**1**
2	F	L	S	N	H	FI	W	A	M	**3**
3	M	L	U	N	L	FI	D	T	M	**3**
4	M	M	S	Y	H	FI	W	G	L	**1**
5	F	M	U	Y	H	FI	T	A	M	**1**

6	M	M	U	N	L	FD	W	G	L **4**
7	F	H	S	Y	H	FI	W	T	M **2**
8	M	L	S	N	M	FD	T	T	H **1**
9	F	M	H	Y	H	FI	F	G	M **3**
10	M	H	H	Y	L	FD	D	G	M **1**

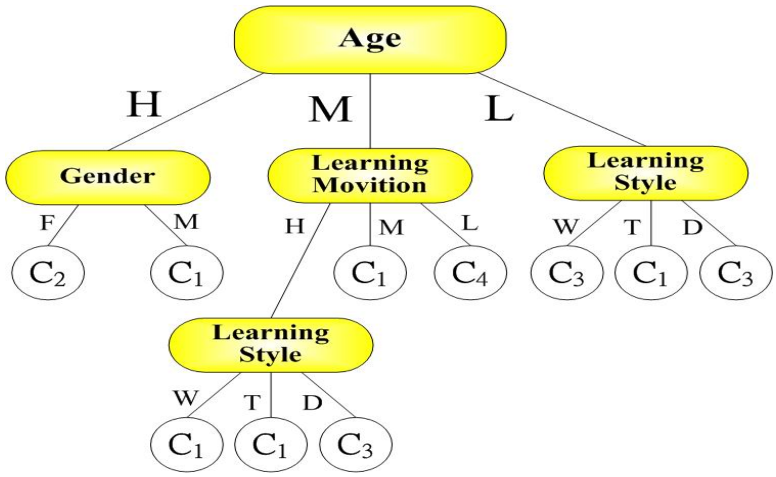

Figure 6. The decision tree based upon the learner profiles in Table 6

Activity Tree Generation Phase

Finally, based upon the created decision tree, we can assign a new learner to a suitable cluster which contains several learning guidance. Each cluster contains a cluster centroid which corresponds to several learning patterns as sequencing rules in sequencing and navigation (SN) of SCORM 2004. Therefore, in this paper, we propose an algorithm to transform learning patterns of cluster into sequencing rules and then create the personalized activity tree, as shown in Figure 7.

Algorithm: Personalized Activity Tree Creation (PATC) Algorithm

Symbol Definition:
LI**:** The set of learning items in a learning activity.
CC**:** The corresponding learning patterns in Cluster Centroid
LP**:** The set of Learning Patterns
VA**:** Virtual Aggregation Node
SCO: The Sharable Content Object (SCO) of SCORM standard
Input: Learning Items (***LI***) and corresponding learning patterns (***CC***)
Output: Personalized Activity Tree (***PAT***)
Step 1: ***LP*** **= {** *lp* | for *lp*∈ CC}
Step 2: For each lp_i

1. Create a ***VA*** with sequencing rules: "*Flow=true*", "*Forward Only=true*", and "*Rollup Rule=All*".
2. The ***VA*** links every item as SCO in lp_i in order.
3. Set All SCOs with Rule,"if NOT complete, Deny Forward Process".

Step 3: If ∃ the same SCO in different VA,
Then create a ***Learning Objective*** to link these SCOs.
Step 4: ***ItemSet*** **=** { *x* | for (*x*∈ *LI*)∩(*x*∉ CC)}
Step 5: Create a ***VA*** with sequencing rules, "*choice=true*" and "*choice exit=True*", to link all items as SCO in ***ItemSet***.
Step 6: Create a ***Root Aggregation*** node with sequencing rule, "*Flow=true*" and "*Choice=true*", to link all ***VAs***.

Figure 7. The algorithm of personalized activity tree creation (PATC)

For the data of Cluster 2 in Table 5, the results of PATC algorithm are shown in Figure 8. Firstly, in Step 1, the ***LP*** will be inserted five learning patterns according to the centroid of cluster 2, i.e., ***LP***={A→D→G, B→C→G, C→D, A→H, A→J}. In Step 2, because a learning pattern, which contains several items as SCO in SCORM, e.g., the item A in pattern A→H, represents an effective learning sequence, we can create a virtual aggregation node as a sub-activity to aggregate all items in learning pattern in order. Here, A Sharable Content Object (SCO) denotes "*a set of related resources that comprise a complete unit of learning content compatible with SCORM run-time requirements*" (SCORM, 2004). Moreover, in each SCO, we set its sequencing rule with "*if NOT complete, Deny Forward Process*" for controlling the navigation order. In order to make learners complete all learning objects (SCO) and satisfy the pass condition, we set the Rollup rule as "*All*". The rules, *Flow=true*" and "*Forward Only=true"*, can forbid learners to learn backward. In addition, a *learning objective* is created to link the same items appeared in different learning patterns. By setting the value of *learning objective*, we can forbid to learn an item repeatedly. For example, in Figure 8, the *learning objective*, called OBJ-A, links the SCO A in Aggregations 1, 3, and 4. After learner satisfied the SCO A, the OBJ-A is set and then the SCO A in Aggregations 3 and 4 will be skipped. In addition, the frequent learning patterns may not contain all learning items in the learning activity. Thus, we also create an aggregation node as referable learning activity to link these items which are not contained in learning patterns, e.g., in Figure 8, the Aggregation 6 contains {E, F, I} and rules, "*choice=true*" and "*choice exit=True*", for free navigation. Finally, the root aggregation node is used to link all aggregation nodes.

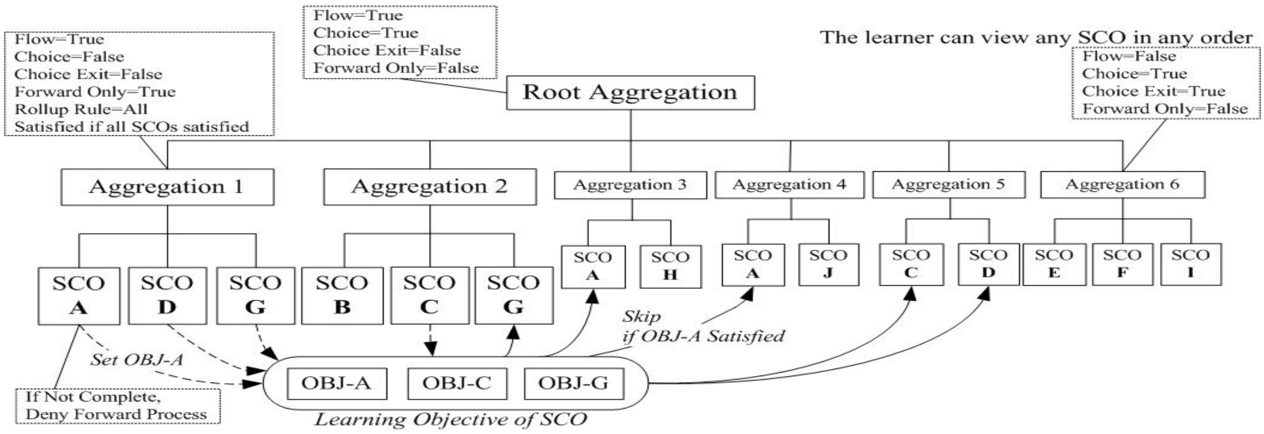

Figure 8. The result of PATC algorithm based upon cluster 2

Therefore, according to PATC algorithm, we can create personalized activity tree, which can be executed at SCORM compliant learning environment, for every cluster. Thus, for a new learner, we can first use the created decision tree to choose a suitable cluster containing learning guidance of several similar learners and then offer her/him the corresponding personalized activity tree to learn.

Implementation and Experimental Results

The Implementation of LPM approach

For evaluating the LPM approach, we implement the LPM system and a training system developed by Java language to gain the training data of LPM system. As shown in Figure 9, the training system can let teachers import their learning contents which were organized into hierarchical structure and then display the index of learning contents for learners.

During learning, the training system will display the learning content and the index of its sub-learning contents after each learner chooses an interested content, where the index order is random because learners are apt to choose the top learning content in the index list. Afterward, according to the learning records obtained by training system, we can use the LPM system to generate several personalized SCORM compliant learning course. Figure 10 illustrates an example of generated SCORM learning course executed on SCORM Run Time Environment (RTE). In Figure 10, the right part shows the learning content and the left part shows the index of contents which a learner can select according to her/his current learning results. Namely, SCORM RTE will automatically control the display of contents according to the associated sequencing rules within the SCORM compliant course. Besides, learners can use the button in the top part to *continue*, *suspend*, or *quit* the learning activity. For example, in Figure 10, learners can choice any aggregation in left part to study because of the root aggregation with sequencing rules, "Forward Only=*false*" and "Choice=*true*". For an aggregation with sequencing rules, “Forward Only=*true*” and “Choice= *false*”, its included content indexes will be hidden, such as aggregations 1 to 5. In other words, learners have to follow the personalized learning guidance and use the continue button to study next course. In addition, the included contents of aggregation 6 as stated in Activity Tree Generation Phase can be viewed by learners in any order.

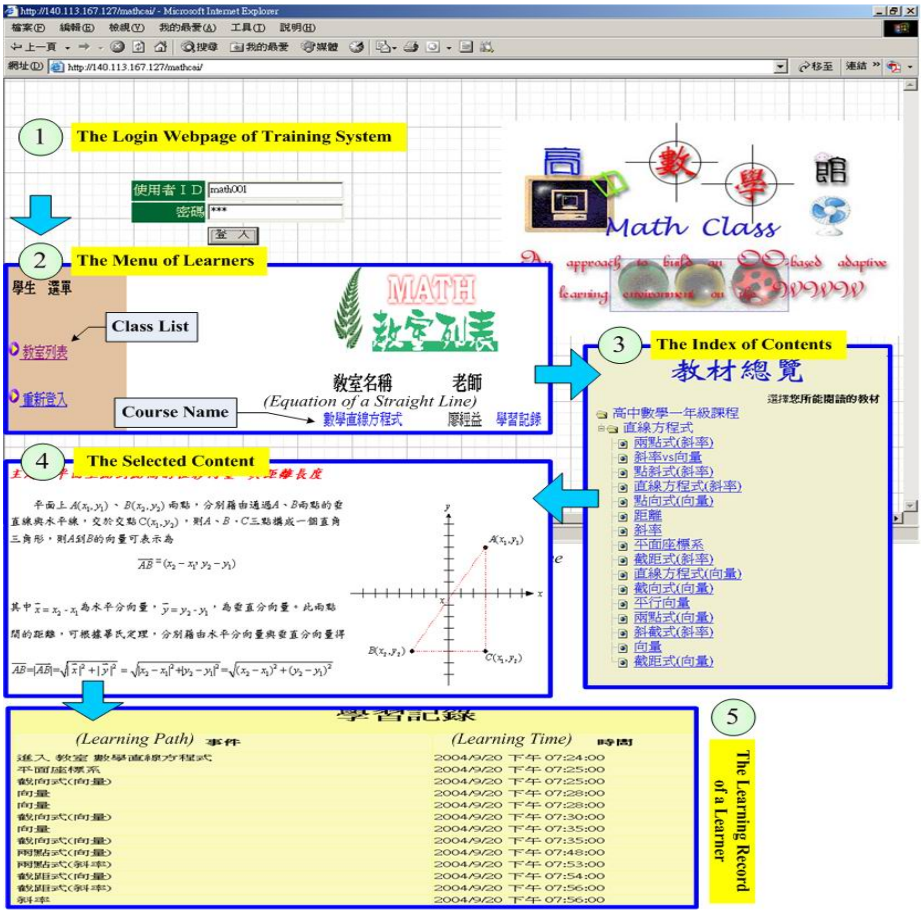

Figure 9. The learning process of training system to acquire learners’ learning behavior

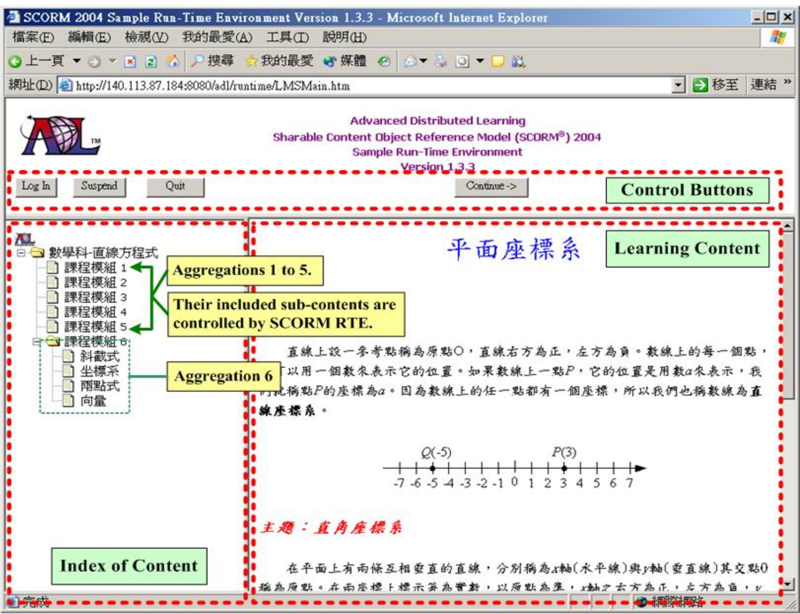

Figure 10. The SCORM learning course executed on SCORM run time environment (RTE)

The Experimental Results and Analysis

To evaluate the efficacy of the LPM approach, an experiment was conducted from September 2004 to November 2004 on the *Equation of a Straight Line* course at a high school in Taiwan. The participants of the experiment are the Ninety students from two equal-sized classes, one is the *control group* A and the other is the *experimental group* B, taught by the same teacher. Before learning, the students in two groups filled out the questionnaire for acquiring their learning characteristics. Then, in Group A, the students use the training system to learn for gathering the training data. Thus, the learning sequences of students with high learning performance in Group A were used to extract the learning patterns, create the decision tree, and generate the activity trees by LPM system. Thus, we gained a decision tree with 5 clusters and 5 personalized activity trees in SCORM compliant course. In Group B, all students were partitioned into 5 groups by the created decision tree and then each group leaned the corresponding SCORM course in SCORM RTE 1.3 as shown in Figure 10. Finally, the testing results in Group B were analyzed by t-test approach.

Table 7. t-Test of the test results (α=0.05)

Classes	N	Mean	S.D. (Standard Deviation)
Group A	45	66.11	10.86
Group B	45	75	12.24
Improvement (B-A)		8.89	

t-test

Variable	Variances	df	*t* Value
Grade	Equal	88	3.64
Grade	Unequal	86	3.64

Equality of variances

Variable	F Value	Pr>F
Grade	1.27	0.4302

The t-test values of the testing results are listed in Table 7. According to the mean value of the testing results, Group B performed better than Group A. By performing the t-test, it is deduced t=3.64, which implies a significant difference between the performance of Groups B and A in the testing Results (where the *t*-value of ‘‘Equal’’ variances is adopted because the ‘Pr>F ’’ value is 0.4302). Therefore, we can conclude that Group B achieved a significant improvement compared with Group A after receiving learning guidance by the personalized SCORM courses.

Conclusions

With vigorous development of the Internet, e-learning system has become more and more popular. How to provide customized course according to individual learning characteristics and capability, and how to create the activity tree in SCORM 2004 with appropriate associated sequencing definition for different learners become two important issues. Thus, in this paper, we propose a four phase Learning Portfolio Mining (LPM) Approach, which uses sequential pattern mining, clustering approach, and decision tree creation sequentially, to extract learning features from learning portfolio and to create a decision tree to predict which group a new learner belongs to. Then, in the last Phase, we also propose an algorithm to create personalized activity tree which can be used in SCORM compliant learning environment. The analysis of experimental results by performing the *t*-test also shows that this LPM approach is workable and beneficial for learners. In the near future, we will extend the user model definition and enhance our mining approach for providing learners with more personalized learning guidance.

Acknowledgment

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Pretoria to Khartoum - how we taught an Internet-supported Masters' programme across national, religious, cultural and linguistic barriers

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ABSTRACT

This article tells the story of the design, development and presentation of eighteen months of coursework for a Master's degree programme in Computer-Integrated education at the Sudan University of Science and Technology in Khartoum from 2002 to 2004. The focus is on what was learnt in adapting a programme presented at the University of Pretoria to cope with the challenges of teaching at an institution thousands of kilometres away, where technological infrastructure, time and policy issues; and even the weather played an often disruptive role. The data sources from which the story is constructed are field notes and preparation material, the project diary, informal discussion both physical and online; interviews and email messages with students, local facilitators, local administrators and presenters; as well as the electronic artefacts produced by the students. A comparison between a synthesis of the literature and the narrative description leads to the identification of seven assumptions that may guide the design, development and presentation of international, cross cultural Internet-supported teaching initiatives.

Keywords

Blended learning, Multi-cultural education, Internet-supported education, Distance education, Computer-assisted education

Introduction

At the beginning of 2000 I was asked to present the University of Pretoria's Masters' degree programme in Computer-Integrated Education at the Sudan University of Science and Technology (SUST) in Khartoum, under the sponsorship of the UNESCO Institute for International Capacity Building in Africa (IICBA). Instead of imposing a foreign degree on the local university I had to help them develop their own sustainable qualification. The SUST senate approved a qualification consisting of ten courses, identical to those of the University of Pretoria Masters' degree, and a mini-dissertation. Twelve exceptional graduates of the four-year Bachelor of education of SUST were recruited in 2002, and were given six months of English language and computer literacy training in preparation for the Masters' programme commencing in January 2003. The presentation mode was a mix of contact and Internet-supported distance education.

This article is a reflection on the eighteen-month process. It relates the successes, failures and practical implications of teaching across national and cultural borders. I was both participant and observer. I participated as programme designer and coordinator, as well as the presenter of a number of the courses, and observed the behaviours of the students, facilitators and administrators, and my colleagues who assisted in teaching some of the courses.

Theoretical underpinning

The programme that is researched and the research itself are rooted in constructivist theory. The programme was designed for students to construct their own meaning, which would be relevant to their own situations, while I present my own reflective construction of what I learnt. It is up to the reader to construct meaning based on an interpretation of all this.

The pedagogical point of departure for the design and presentation of the programme was Merrill's (1991) six guidelines for instructional design: Learning is constructed from the experience of the learner. Interpretation is personal. Based on their own knowledge and experience individual learners make different interpretations of the same material. Learning is an active process whereby experience is converted into knowledge and skills, instead of being "taught". Learners should be given learning tasks that they can only complete by acquiring the prerequisite knowledge and skills. Learning is collaborative and enhanced by multiple perspectives. Knowledge is situated in real life and that is where learning should take place. Testing should be integrated with the task. My co-presenters and I adhered closely to the five principles of constructivism presented by Brooks and Brooks (1993) who argue that problems must be relevant to students, the curriculum should be founded on primary concepts, teachers should seek to understand and value students' point of view and adapt the curriculum accordingly, and that authentic assessment should serve rather to assist the learner than to determine a grade. Other authors who guided our thinking include Hannafin and Peck (1988), who believe that "learning may be more efficient when the instruction is adapted to the needs and profiles of individual learners"(p. 48), and Papert (1993) who coined the term *constructionism* for the process of assigning tasks from which people learn.

The practical design and execution of the programme took note of Daniels (1999) who points out the advantage of international collaboration in allowing students and instructors to develop enhanced linguistic and cross-cultural skills, and mentions institutional administrative and policy factors as barriers for international cooperation. Administrative aspects that come into play are differences in academic schedules, group sizes, and assessment criteria as well as the challenge of cultural and language barriers.

Research method

This ethnographic case study investigates the socio-cultural and educational context (Ellis & Bochner, 1996) of a clearly delimited group of participants (Yin, 1989). The data sources were my own lived experience, field notes and preparation material, the project diary, informal discussion both physical and online, interviews and email exchange with students, local facilitators, local administrators and my co-presenters; as well as the electronic artefacts produced by the students in the form of essays, term papers, websites, *PowerPoint* presentations, *Authorware* lessons and *Excel* spreadsheets. Data was subjected to a classical analysis (Ryan & Bernard, 2000) involving a scrutiny of all the products to determine the emerging patterns, and to classify them in terms of the assumptions derived from the literature. Member checks (Merriam, 1988) occurred as seminal versions of this article were sent to participants, and comments received were worked in.

A limitation of participatory ethnographic research is that it can be clouded by personal bias (Ellis & Bochner, 1996). Attempts to counter this include multiple sources of data, as well as regular consultation with co-presenters, and discussions with the students. I lay no claim that these results can be generalised, but present them here hoping that they may resonate with similar findings of other researchers (Berg, 1989) and contribute to the body of unfolding stories about international collaboration across national and cultural borders with various blends of contact teaching, co-operative learning and Internet support. The strength of qualitative research lies in rich and thick description (Merriam, 1988). Here follows a detailed narrative account of the history, development and running of the programme and the responses of the participants.

Background

Since 1992 the University of Pretoria (UP) has presented a two-year Masters' Degree programme in Computer-Integrated Education (CIE). The programme is made up of 18 months' coursework and a mini-dissertation. The presentation mode is that we meet once every six weeks on Wednesday and Thursday for feedback and examination of the past course, and on Friday and Saturday to discuss the work for the next course, and workshop essential concepts. All materials are available on the Internet. Between meetings lecturers and students continue discussions on an email discussion list.

Sudan University of Science and Technology has a faculty of Education and a department of Computer Science, as well as a centre for computer-based education, but has never offered any courses in computer use in education. Although Sudan is one of the poorest countries in Africa the university has an excellent computer infrastructure, and Internet connectivity, though with very limited bandwidth. The Sudanese Ministry of Education and Ministry of Technology had been planning the introduction of computers into schools in Sudan, but teacher training was a constraint. It was decided to develop capacity in this region by offering bursaries to promising Bachelor of Education graduates for a Masters' programme in Computer-Integrated Education. Upon completing the programme they would train teachers in Sudan. The UP M.Ed. (CIE) degree was selected for our curriculum, presentation mode, cost considerations and African orientation. An existing cooperation agreement allowed easy exchange of staff and students between UP and SUST. Both institutions have British colonial roots and have a typically British academic "look and feel" and structure.

The Republic of Sudan is the country with the largest surface area in Africa. It is also one of the poorest. It forms the meeting place between the Afro-Arabic states to the north, and Coptic Christian states to the south. For many years it has been plunged in a civil war, which means that much of the little financial resources it does have, are spent on the military. Apart from the obvious poverty there is no evidence of war in the capital, Khartoum, which is a typical African metropolis with a few exclusive and expensive Western-style hotels flanked on all sides by indigenous hotels, small businesses and housing.

Project description

The preparatory visit

I visited Khartoum for the first time for four days in August 2002 to meet with the role players. I met the Sudanese ministers of Education and of Technology, the Vice-Chancellor of SUST, the Dean of the Education Faculty, the programme steering committee, programme facilitator and tutors; and prospective students. The facilitator was a Caucasian American Muslim who was also their professor of English and Research Methodology. The two part-time computer literacy tutors were full time students on the M.Sc. Computer Science programme of SUST.

The presentation mode was that a Pretoria instructor would spend four or five days on a contact visit with the students every eight weeks and then support them via the Internet in the intervening period. The local facilitator and tutors would meet the students weekly and see to their day-to-day needs. For the first visit we would spend a total of four days getting to know one another, exchanging expectations about the programme, doing general administration and introducing the first two courses. All subsequent face-to-face meetings would also be four or five days long. The first few days would be spent completing the current course, while the last days would be for introducing the students to their next course.

I went on an extensive tour of the campus, saw various computer laboratories, and attended examination sessions where computer science students demonstrated their final year projects. The standard of teaching and the computer facilities were excellent, but bandwidth constraints made Internet access during class time almost impossible.

We planned the presentation schedule for 2003 and 2004 and drew up a provisional timetable. Fitting the programme into a two-year calendar seemed ridiculously easy. SUST has a timetable-based undergraduate programme, but graduate students attend throughout the year. There was no need to fit in with the rest of the university, besides which it was impossible to obtain a copy of the official university undergraduate timetable, which would have enabled me to slot some of my classes into times when the undergraduates were off campus and not using bandwidth. We therefore negotiated with the students to have contact sessions on Friday – the Sudanese (Muslim) holiday – and they could take another day off for their holiday. The students, having been selected for their high levels of motivation, performance and dedication, agreed. Furthermore, I could not find a record of Sudanese national holidays on which it may be improper to teach. I therefore labelled my timetable "provisional", and returned to South Africa.

A few days before the official commencement of the programme I obtained email addresses for all students and the facilitator and registered them on a *Yahoo groups* discussion list. I put the course objectives and learning tasks on the Internet, providing links to provisional readings and to all the websites students would need to perform the tasks.

The first academic visit

Upon booking my flights for the visit I learnt that the earliest return flight would be at 03:40 on Wednesday morning. The visit would be for five days. We would cover the contact work for two courses: *Evaluation of software and its effect on learning* and *Learning theory for computers in education*.

I had timetabled the first session to start at 08:00 on Friday January 10, 2003. When I was collected from the airport the Thursday night I heard that the students used public transport and could not make it before 09:00. The prescribed textbook (Alessi & Trollip, 2001) had been obtained, but would only be available on the Saturday, as Friday was the national day of rest.

On the first day we registered all participants on *Yahoo groups*, our principal means of communication between contact sessions. At 11:00 "breakfast" arrived, in the form of a platter of refreshments. This was unexpected. I did not know that 11:00 was breakfast. I had no idea of the rhythm of a Sudanese working day. I had planned to break for lunch at the traditional South African time of 13:00. After breakfast we discussed our mutual expectations, and I handed out the work for the next three days. Students had to present individual lectures on various topics concerning learning theory for computers in education, and evaluation of software. At some stage students disappeared for prayers, and returned a short while later. We continued some more and ended the day at 14:30 to allow them to prepare at home.

The second day, Saturday, we workshopped the presentations that they would do on Sunday. It was becoming clear that they were very uncomfortable with the degree of freedom they were allowed in terms of what I expected of them. So much for flexibility! They wanted clear guidelines, but, working from a constructivist, learner-centred perspective I was not going to give it to them. They had to continue discovering valid information and process it into units that were palatable to their peers.

We broke for lunch at 13:00 and some of students and I went to the student canteen together with the facilitator and tutors. During this informal discussion it became clear that students felt it wrong that someone from outside, with no local knowledge, was teaching them. My explanation that I was providing the core, and that they had to add local relevance, did not satisfy them. I therefore suspended the activities of the third day, Sunday and replaced it with a field trip. A committee of students determined the itinerary, and arranged a full-day tour of Khartoum to introduce a foreign education consultant to the diversity of the situation.

We visited the University of Khartoum school of Art and Music, a number of state-run junior and high schools for boys and girls, and we visited a brand new private high school that had just been constructed. Figure one shows scenes from two computer laboratories in such schools.

Figure 1: School computer labs in Khartoum

I learnt how to say *Salaam alaikum* (peace be with you) and *sookran*, (thank you) and generally socialized with the students. We also visited two of their homes – one in a well-to-do area on the banks of the Nile, the other in an average area. Thus more trust was built up between the students and me, and their anxiety levels were considerably reduced.

The students' first learning task was to evaluate educational software of their choice on a target population of their choice. They had to conduct static evaluations on three pieces of software in groups of three, but give individual feedback, each on one program. They had to make recommendations about implementing the program in their situation. The students spent Monday morning presenting their mini workshops on the general topics given to them, and the afternoon evaluating software for their feedback sessions on Tuesday. Their confidence increased considerably as they received affirmative feedback on their workshop presentations.

There are a number of Sudanese programs on the market, and the SUST multimedia section had already developed some of their own, but the students nevertheless opted to use programs I had brought along. These were regular commercial titles from the Davidson, Dorling Kindersley and Jumpstart stables, as well as a few titles produced by my own students as part of their *Authorware* courses in previous years.

The screen captures of the students' *PowerPoint* presentations, illustrated in Figure two show that they conformed rigorously to the framework that they were given but the actual written assignments showed substantial flexibility in their approach to using international software that might not necessarily be suitable for Sudanese use. A student evaluating *Magic School Bus* found that it would be useful for Sudanese learners across the economic and gender spectrum, with minor revisions to language, since 35% found the language acceptable and 50% found it “too easy”. Two students independently evaluating *Reader Rabbit* found it to be motivational and useful for Sudanese learners. Both commented that the pictures should be more carefully matched to the text, but had no problem with the ethnic biases of the pictures. One recommended that the program should allow temporary termination, and the other that the teacher be present to support slower learners.

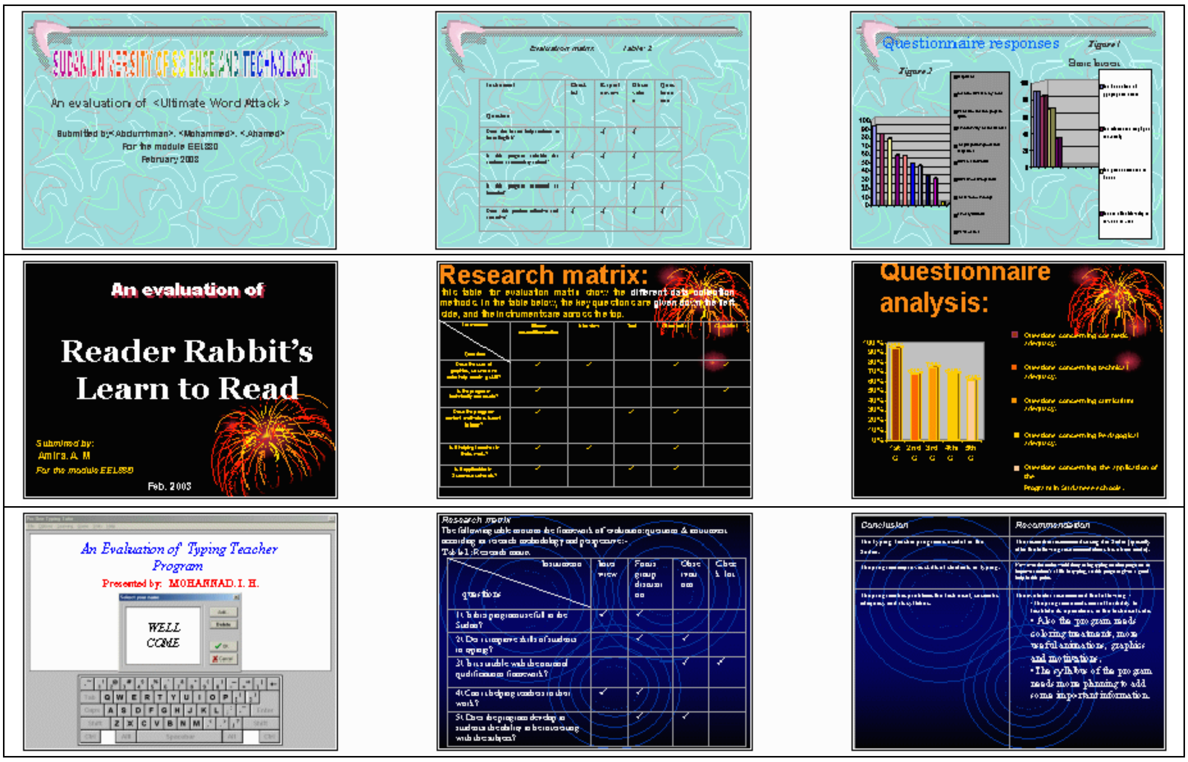

Figure 2: Screen captures from PowerPoint evaluation presentations

For their final project – an essay reporting on a dynamic evaluation of a piece of software of their choice – I realized I had to give more scaffolding than I would have given to my South African students. I therefore developed a template essay and a spreadsheet-based assessment rubric. I divided the students into support groups so that they could assess one another’s projects before hand-in. We re-negotiated hand-in dates as well as the times of my next visit.

I took them through a sample essay of a South African student and worked through the assessment rubric. The self-assessment and peer assessment had to accompany the final document. In this way I was hoping to achieve the highest level, *evaluation*, on Bloom’s (1956) taxonomy without causing distress to the students.

The plan was that the students would complete their evaluation assignments and submit them after four weeks. Then they would meet with their local facilitators and start with the theoretical work for the learning theory course in preparation for my next visit. We finished late on Tuesday afternoon and I departed for Pretoria at 03:40 on Wednesday morning.

Most of the student assignments arrived on time via email. A few assignments were handed in late on account of technical problems in Sudan such as non-availability of computers and Internet downtime. All had assessment rubrics as attachments. Table one shows the grades they gave themselves, and the grades I gave them.

In most cases the students were slightly more generous with grades than I was, but in only two cases was the discrepancy higher than 5% , and in both cases the students under-evaluated themselves. The two candidates in question, Ta and Om were among the stronger ones. Subsequent interviews and reflection revealed that one, a very diligent female student, did not believe she could achieve so high a grade, and went back and brought some assessments down. The other student, who calls himself “the naughty one”, had similar doubts about his performance. Nevertheless these two students found the experience a valuable lesson in meta-cognition, and in taking responsibility for their own learning.

The high degree of correlation was due mainly to the mechanical nature of the rubric, which consisted of 54 items to be checked on a scale that ranged between two and five points. The advantage of the system was that students felt comfortable with the way in which they were assessed. The disadvantage was that, at Masters' level, I felt uncomfortable with the equally mechanical quality of the work that was produced.

Table 1: Student self-assessment compared to my assessment

Student	Own grade	My grade	Difference
Id	76	76	0
Md	83	86	-3
Ab	70	68	2
Ha	75	75	0
Ma	74	69	5
Ta	68	82	-14
Ka	53	51	2
Ib	70	73	-3
Yo	91	86	5
Om	70	82	-12
Ia	70	67	3
Et	89	85	4

The second academic visit

On my arrival on Saturday, 22 March I learnt that a computer laboratory that was promised specifically for our students had not materialized, and the very luxurious, high-bandwidth facilities of a private institution, the Khartoum Academy of Technology (KAT), had been rented for our use.

Much of the second visit was spent catching up on work that should have been done while I was away. The second course, dealing with learning theory for computers in education should have started in my absence. The plan had been that I would finish it off with them and start on the third. I had emailed work to the facilitator to distribute among the students, but computer laboratory constraints prevented them from working, so they had done very little preparation and I had to help them catch up.

Students expressed extreme dissatisfaction with the lack of support that they were getting from their own institution. Nevertheless, once their anxieties about their unfinished work for the second course had been addressed and new deadlines had been negotiated they seemed to be more at ease.

I also realized that I would have to spend more time on their third course – one on tutorials, drills, simulations and games – during this contact session to avoid our falling behind again. I therefore dealt with the contact work of both courses during the one visit. We lengthened our contact sessions and met from 09:00 to 21:00 instead of 09:00 to 16:00.

Learning theory for computers in education

For the learning theory course students had to design a computer-integrated co-operative learning (Johnson, Johnson & Smith, 1991) event along *instructivist* principles, in particular Gagne's (1987) events of instruction and try and reach as high a level as possible on Bloom's (1956) taxonomy of the cognitive domain. However, the catch was that they were to allow the lesson to occur in a *constructivist* fashion. They were to present this learning event to a target population of their choice, record the event with a digital camera, debrief the learners on the event, assess the learning that had taken place and write up what they had learnt in a paper of 3000 words. They were also to edit the video to ten minutes and embed it in a *PowerPoint* slideshow.

Although they had dealt with constructivism in their undergraduate years, they were *taught* about constructivism during typical instructivist lessons. Apart from the work that they had done with me for the previous course they had no experience of constructivism. I would have to monitor their progress carefully to avoid their slipping into "chalk and talk" reinforced by computer-based drill and practice. Thus we spent a day discussing the possible learning events that they may present, and sharing ideas of how to improve these, working in small groups. Then they presented their plans individually to the class and to me. Once they had received feedback, they drafted learning event protocols according to a template I provided.

In the time before our next contact session, they would email me their learning event protocols as well as any spreadsheets, worksheets and slideshows that they would use in the lesson. I would critique them publicly via the class *Yahoo groups* discussion list. They could fix it up and re-submit, concentrating on improvement, rather than on the grade they wanted. The students were happy that they could submit their lesson protocols for comment before presenting the lessons.

Our third contact session would be devoted to their oral feedback, illustrated with the video-embedded *PowerPoint* shows. I wanted them to see what their lessons looked like. Table two is an example of an initial protocol that was submitted for discussion.

Table 2: Example of a learning event protocol

Subject area: French grammar "Le passé composé"
Expected outcomes:
After this learning event, students should be able to:
Identify the rules of forming the past participle of French verbs from first, second and third group.
Construct the past participle of French verbs from first, second and third group.
Distinguish between the past "passé compose" form and the present form.
Identify the structure (rule) of "passé composé".
Utilize the passé composé in real or different contexts.
Identify the verbs that are used with auxiliary être (to be in English).
Make the « accord » of verbs with subject when the auxiliary 'être' is used.

Time	Learner activity	Facilitator activity	Resource	Rationale
10 min	Do an exercise as pretest.	Observe, asses for comprehension level	Written exercise (pre test).	Assess students' comprehension extent about the lesson.
5 min	Listen to introduction about the lesson objectives, procedures & procedure (plan).	Introduce the lesson objectives, procedures & activities (plan)	Verbal information	Make students aware about the lesson objectives, procedure &activities.
5 min	Read &discuss a list of given verbs (from 1st, 2d, 3rd group) and their past participles through a table.	Observe, animate the discussion, and check for accuracy.	Table on word processor. List of verbs from different groups	Make students aware about the difference in forming past participle of verbs from 1st, 2d &3rd groups.
5 min	Complete the given table by giving the P.P of the rest of verbs from each group.	Observe, encourages students to work and provide feedback.	The previous table of verbs	Encourage the students to know the rules of forming the 'P.P" of verbs from different groups and applicate these rules.

Drills, tutorials, simulations and games

Despite the six-month intensive language course, students struggled to express themselves in English. The grading of their previous essays showed that their academic skills and subject knowledge were securely in place, but their English writing skills were a barrier. I decided to work around that by letting them do projects that would involve much reading and thinking, but little writing. I designed embedded assessment strategies focused on measuring their understanding of teaching with computers, rather than their knowledge of English.

Students were placed into co-operative learning groups designed according to Johnson, Johnson & Smith's (1991) "jig saw" model. They had to read through the chapters in Alessi & Trollip (1991) about tutorials, drills, simulations and games. Then they had to compile an *Excel* spreadsheet with check box responses to sixty questions. Based on the answers to those questions the spreadsheet should prescribe the extent to which a given learning need would be best served by either a tutorial, drill, simulation or game. The twelve students were divided into expert groups each concentrating on one of the four modalities, and home groups consisting of a designer, a spreadsheet programmer and a writer. Thus they would focus on primary concepts, but the group members would bring multiple collaborative perspectives. The spreadsheets were completed during the contact session.

The spreadsheet tasks completed under my close supervision were of very high quality both technically and in terms of content, though the English language usage of the questions was still poor. Essentially the four groups produced spreadsheets that asked the same questions, because the expert groups formulated them together. The sheets differed in the weighting of each statement, as the home groups negotiated this. The individual designs of the spreadsheets also differed according to group preferences (See Figure three).

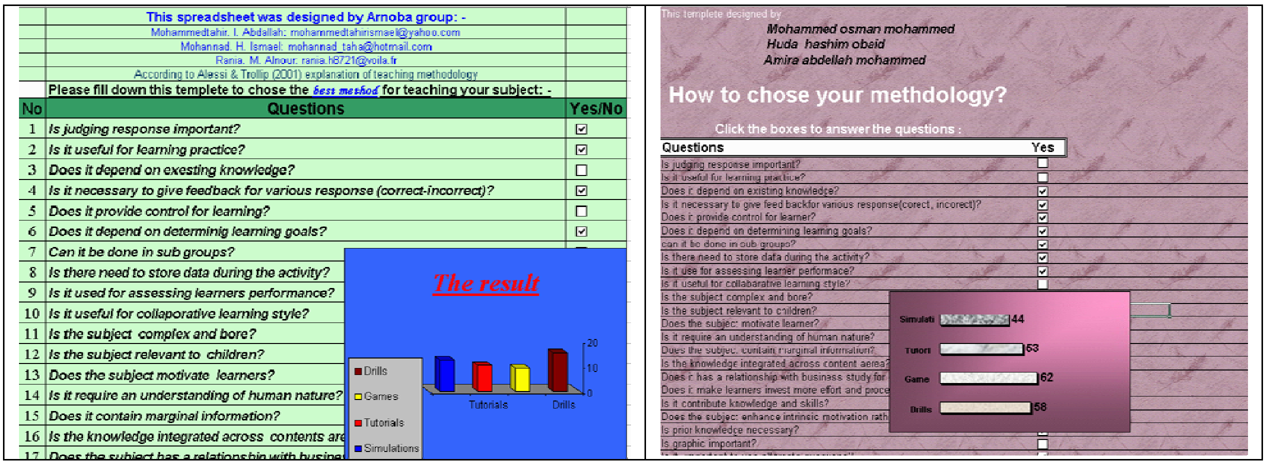

Figure 3: Spreadsheets of two groups showing different interpretations of the same task

The second task was for students individually to design a *PowerPoint* tutorial of sixty screens that would teach about tutorials, drills, simulations and games in their subject area or work environment – to allow personal interpretation of primary concepts. The slideshows were to be submitted to me via email.

We ended the visit with an evening picnic on the banks of the Nile, eating American-style pizza, and drinking African Muslim style non-alcoholic bottled sodas.

The work I received via email was excellent. Students submitted lesson protocols as *Word* documents with sound clips inserted. They designed worksheets in the form of macro-enabled *Excel* spreadsheets and interactive *PowerPoint* slideshows. Most work arrived punctually and students who asked for extensions met their revised deadlines. An analysis of the work showed clearly that the students had constructed their own learning from their own points of view.

The third academic visit

The third contact visit, starting on 24 May and held once again at KAT, was uneventful, but the temperature was 41 degrees Celsius and very humid. The annual Khartoum rain had fallen the previous day. All over the city people were using air conditioners, leading to frequent power cuts. We could hardly use our air conditioning, computers or data projector. We spent the first two days debriefing students on their lessons, watching and discussing their movie clips, and giving feedback on their *PowerPoint* shows on tutorials, drills, simulations and games.

Instructional design

The fourth course had to prepare students for the fifth course, which, according to our agreement, would be a locally delivered course on developing educational multimedia with *Macromedia Authorware.*

Students had to prepare needs assessment documents, design specifications, instructional design blueprints, and a *PowerPoint* mock-up of the project that they would produce for course five. On account of the power cuts we did this with paper and wax crayons. They emailed their electronic design specifications, blueprints and other documentation for me to critique via the *Yahoo groups* distribution list, so that all could learn from my feedback on each individual submission. Then they set about collecting material for the *Authorware* sessions.

Two more visits

Many emails from dissatisfied students indicated that they were unhappy with the locally delivered *Authorware* course, so I asked a colleague and *Authorware* expert, Dr Dolf Steyn, to present course six on project management starting on 14 August. We re-curriculated it to include a revision of *Authorware*. Students, in two project teams of six members each, had to run a project in which they designed and constructed yet another program in *Authorware*. They were highly satisfied with the course and requested Dr Steyn as presenter for course seven starting on 2 October. For this course on learning with databases they had to construct relational databases that yielded bibliographical information about literature on constructivism and computers, objectivism and computers, computers and individual learning, and computers and cooperative learning. The rationale for this task was to reinforce the course on learning theory that was skimmed over owing to time constraints earlier in the year.

An unanticipated break

Course eight, on Internet-based education, should have started towards the end of November, but when we discussed a date with the students they said that couldn't do any work in the month of Ramad'an (November) as they would be tired from fasting all day. This information had not been shared with me in the planning stages in January, and I had to deviate once again from the "ridiculously easy", "provisional" timetable. I could not go in December since increased air traffic over the festive season made it impossible to find reasonably priced air tickets. I therefore ran course eight on "Internet-based education" *via* the Internet during December and the first half of January. For this course they had to construct an annotated webliography on Internet-based learning, and design their own websites with portfolios of all the work they had done thus far.

The last two contact sessions

We presented the contact sessions for the last two courses in Khartoum from 15 to 22 January 2004. Course nine was about implementing computers in schools, and course ten on computer use in classrooms. The two were presented in tandem and with the help of Prof. Seugnet Blignaut of the University of Pretoria.

Strategic planning for computers in schools

The contact session for course nine consisted of a two-day seminar on effective computing in schools attended by delegates from the Ministry of education, as well as principals of local schools. We took the delegates through the process of analyzing, planning and implementing computers in schools from a strategic, tactical and operational perspective.

During this seminar I learnt my most valuable lesson in teaching across national and cultural borders - the importance of presenting *core* material rather than application. I suggested that before a school could determine an implementation policy it would have to take note of government policy. What is government's purpose with education? Once you know that, you can determine the role of computers in helping your school achieve government's purpose. In my country, I said, the purpose of education is economic empowerment: To help people get jobs and make money. I added that it was probably the aim of all education. A representative from the Ministry of education interrupted me. "In this country," he said, "The purpose of education is to teach people to live together in peace and harmony". This was greeted with much enthusiasm from the audience. I had forgotten that in their war-torn country, they had more important things than money on their minds.

After the two-day seminar the students had to go to one of the schools whose principals had also attended and, in co-operation with the principal, develop an implementation plan for the school.

Computers in the classroom

For course ten, students had to use *PowerPoint* to develop a "mindtool" for use in the classroom, and perform a formative evaluation of the tool. In this way the final course linked up with the first one on evaluation of software and its effect on learning. Students were encouraged to use the mindtool as the basis for their three-month mini-dissertations that they would write in Arabic under local supervision. Prof. Blignaut also presented a two-day workshop on writing a research proposal and conducting development research. She undertook the last contact visit when she debriefed the students on their experiences, graded the presentation for course nine and ten, and refined their proposals with them.

Finishing off

On completion of the ten courses there was time for students to complete any unfinished projects. While processing the grades I learnt that the pass mark for a Masters' course was 60% and not 50% as in South Africa, and there was no distinction. Thus I had to moderate some results.

Then the chair of the programme steering committee told me that students were only allowed to start their dissertations once I certified that their coursework was complete – another piece of new information. Instead of submitting all their results in one batch I therefore had to submit in drips and drabs over a period of four days as they completed their unfinished tasks. I eventually gave them 24 hours to finish all outstanding work – and they did. One student had health and personal problems and finished a month after the rest, but on 5 July 2004, eighteen months after the official beginning of the programme, I submitted the last grades. The duration of the taught component of the programme had been exactly the same as the one run in Pretoria.

Conclusions and recommendations

This section presents some of the conclusions reached during an analysis of the project data, against a synthesis of the theoretical principles and guidelines for constructivist learning (Brooks & Brooks 1993, Merrill 1991).

The synthesis presents some clear correlations, but also some apparent contradictions. While it is essential to create relevant experiences from which the learner can construct learning, tension develops between the need to ground work on primary concepts while allowing personal interpretation. This is exacerbated when learning is to be enhanced by the multiple perspectives that come with collaborative learning. Finally, moving learning into the real world, while integrating the task and the test in such a way that it benefits the learner rather than just producing a grade requires a great deal of flexibility, both in terms of content area, learning task and deadlines.

The relationship between the two sets of principles can be seen more clearly when they are plotted on a matrix. Table 3 shows a synthesis of the two perspectives, with areas of commonality indicated with ✓, contradictions with #, and aspects that are exactly on target for this study with ◎.

Table 3: Synthesis of principles and guidelines

	Curriculum relevant to students	Focused on primary concepts	Value students' point of view	Adapt curriculum	Authentic assessment	Assessment o support rather than grade
Learning is constructed	◎			✓	✓	✓
Interpretation is personal	✓	#	◎		✓	
Learning is active and converts experience into skills	✓	✓	✓	✓	◎	
Collaboration enhances with multiple perspectives		◎	✓			✓
Learning should be in real life			✓	◎	✓	✓
Testing should be integrated	✓	#		✓	✓	◎

Assumptions

From the "targets" in Table three a number of assumptions can be distilled. They form the basis of the interpretation that follows:

1. The curriculum should be designed in such a way that it provides relevant experiences from which students can construct their own learning.
2. Interpretation is personal and the student's point of view must be valued, but not at the expense of primary concepts.

3. Active learning tasks should incorporate assessment strategies that determine the extent to which experience has been converted into skills.
4. Multiple collaborative perspectives should be focused on primary concepts.
5. The curriculum should be adapted “on the fly” if the real-life situation demands it.
6. Testing should be unobtrusive and focused on determining areas where the student should improve.

The assumptions above seem good on paper, but give rise to practical problems. As they stand they call for a high level of administrative flexibility, which is further complicated when one works across national borders (Daniels, 1999), particularly in a country that is five hours’ flying time away. Thus another assumption needs to be added:
1. Administrative flexibility should be designed into the system from the outset.
2. These seven assumptions formed the basis of this interpretation of the findings and will be used as sub-headings.

Assumption one: The curriculum should be designed in such a way that it provides relevant experiences from which students can construct their own learning.

The value of the day-trip with the students to schools and other institutions of note cannot be underestimated. Although the programme was designed from the outset to provide scaffolding of primary concepts the instructors had to develop a feeling for the environment where the students operate. Students had to develop confidence in the instructors’ willingness to allow them to construct their own relevant learning.

The pictures of school computer laboratories captured from the videos of lessons from course two, or contained in the strategic planning documents of course nine give us some indication of the real world in which the students operate. It became increasingly necessary for the instructors to act as *facilitators* of students’ understanding of the situation within the wider context as their mastery of the subject content increased.

Students showed much appreciation for the fact that they could test software on their own pupils, design lessons for their own learners, make spreadsheets to test the appropriateness of drills, tutorials, simulations or games in their own environment, develop *Authorware* lessons for Sudanese learners, and write implementation plans for schools in Khartoum.

Assumption two: Interpretation is personal and the student’s point of view must be valued, but not at the expense of primary concepts.

Presenting *core* material is essential. The stated government policy on the purpose of education differs radically from the South African one, nevertheless, my initial (core) statement remained valid: you have to know what the policy of government (your employer) is, before you can set up your own.

The software evaluation projects showed that, with the fundamentals in place, and primary concepts established, students could add value with personal interpretation.

The self-assessment rubric kept primary concepts in tact, while students explored their own interpretation in their essays.

Assumption three: Active learning tasks should incorporate assessment strategies that determine the extent to which experience has been converted into skills.

Self-assessment and peer assessment rubrics teach students to assess. The embedded assessment strategies in the spreadsheet task, lesson videos and *Authorware* projects emphasized their understanding of teaching with computers, rather than their knowledge of English.

Assumption four: Multiple collaborative perspectives should be focused on primary concepts.

The co-operative learning in the spreadsheet tasks showed they could focus on primary concepts, yet bring multiple perspectives.

Internet-based feedback on student projects delivered between contact sessions was usually presented to the whole group via a mailing list. Students objected to individual feedback as they felt that they might miss valuable information that could be relevant to their own work.

Assumption five: The curriculum should be adapted "on the fly" if the real-life situation demands it.

The excursion added the curriculum of the first visit built trust the students and me, and reduced their anxiety levels.

The spreadsheet exercise shows how the learning task was adjusted without affecting the curriculum outcomes.

Wax crayons and paper are excellent alternative tools for making instructional design sketches and prototypes.

Other examples of the curriculum changing as we went along include repeating the *Authorware* course as part of the project management course.

Adapting the curriculum for logistical reasons by moving the Web-based learning course entirely online had the happy consequence of giving the students a completely online experience of online learning.

Assumption six: Testing should be unobtrusive and focused on determining areas where the student should improve.

The self-assessment rubrics, iterative assessment of learning event protocols, and video assessment of the constructivist learning events are examples of unobtrusive testing focused on improvement rather than grades.

Assumption seven: Administrative flexibility should be designed into the system from the outset.

Administrative flexibility is probably the most complex issue, but also the most important. In the eighteen months of this programme my two colleagues and I had to contend with the minimum information about schedules and timetables, as well as obscure policy and academic procedures. We learnt about prayer times, late breakfasts, transport problems, slow construction times and painfully slow Internet connections. Public holidays intervened. We had to moderate our assessment at the last minute

While we were extending deadlines to accommodate administrative and logistical delays, the institution mandated that they could not continue with their theses unless the coursework had been completed. Our administrative flexibility was, ironically, holding our students back. Flexibility also meant that one sometimes had to be rigorous where others may have been lenient.

Most importantly, what we learnt was that flexibility bred flexibility. Students were prepared to work on their holidays because we would work on ours. Students were prepared to work under pressure of 24 hours completion time, because they knew they had been given extension beyond the reasonable dates.

Finally

To me the greatest success of the programme lay in its 100% completion rate. We completed the programme exactly on schedule, although we had to miss out a two-month period in the middle. Two students got married during the year, and some lost loved ones. Yet all of them finished and the final results compared well with those of their South African couterparts. I cannot say how much of the success is attributable to the assumptions above, and how much of it is due to institutional factors such as bursaries, contractual obligations, rigorous selection or career opportunities, but what I do know is that, if asked, I will do it again.

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Undergraduate Students' Academic Achievement, Field Dependent/Independent Cognitive Styles and Attitude toward Computers

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ABSTRACT

This paper reports an investigation of cognitive styles, achievement scores and attitudes toward computers among university students. Field dependence/field independence is a dimension of cognitive style that has been researched with various student groups as well as with attitudes. Nevertheless, there appears to be a dearth of published research in this area relevant to teacher trainees in an international setting. In this study, the standardised Group Embedded Figures Test was used to assess field dependency among 130 teacher trainees. Overall, it was found that there was no significant relationship between cognitive styles and academic achievement ($r= .14$, $p= .15$); cognitive styles and attitudes toward computers ($r = .01$, $p= .84$); and, cognitive styles and attitudes toward computers when their academic achievement scores were covariated ($F(2,126) = .40$, $p > .05$). The findings indicate that students' attitudes toward computers are not associated with field dependency, even when their achievement levels were controlled. Attitude toward computers is found to function independently from cognitive styles.

Keywords

Cognitive styles, Achievement, Attitudes, Post-secondary education, Pedagogical issues

Introduction

Web-based instruction and the use of information and communication technologies in educational settings are transforming the methods of content delivery and instructional materials. Tomorrow's teachers are now expected to be computer literate and use information and computer technology tools in their teaching profession. Moreover, they are also expected to apply higher cognitive skills, such as collecting, analyzing, evaluating, summarizing, and synthesizing information.

The on-going transformations of educational environments and training future teachers based on those needs make the development of cognitive skills an important indicator of success. Cognitive psychologists and educators have long been interested in understanding the individual differences in cognition and their impact on learning and instruction. Witkin's research (1971), undoubtedly, helped build the field dependency theory to better separate people with one factor from the total visual field.

Providing information and communication technologies (ICT) to schools and teachers are positive steps toward encouraging teachers to take advantage of them. However, research has shown that teachers' attitudes toward computers interfere with their ability to integrate them into their classroom teaching (Chou & Wang, 1999; Tsai, Lin & Tsai, 2001) and the broad diversity of individual differences among potential teacher trainees should be taken into account in teacher training programs (Chou & Wang, 1999; Liu & Reed, 1994). Therefore, it is equally important to equip classroom teachers with appropriate cognitive tools and guide them toward a successful ICT integration. One of the challenges facing educational technologists and instructional designers is in integrating information and communication technologies, which take account of individual differences such as computer use, attitude, and more importantly from an educational perspective, cognitive learning styles. Therefore, one question of specific interest for this study is to investigate the relationship between cognitive styles, academic achievement, and students' attitudes toward computers, described by Lee, Kim, and Lee (1995) as joint contributors to behavior.

Literature Review

Cognitive versus Learning Styles

There apears considerable confusion in the literature concerning the terms cognitive and learning styles. Numerous authors and researchers use the terms interchangeably. However, various authors draw a distinction between cognitive and learning style. Learning styles refer to ways that people learn information, and cognitive styles are more global, referring to the way that people see the world around them and interact with it (Jonassen & Grabowski, 1993).

Ausburn and Ausburn (1978) defined cognitive styles as the "…psychological dimensions that represent the consistencies in an individual's manner of acquiring and processing information (p. 338)". According to Messick (1984), cognitive style deals with the manner in which people prefer to make sense out of their world by collecting, analyzing, evaluating, and interpreting data. These styles are thought to remain consistent preferences throughout life (Jonassen & Grabowski, 1993).

Jonassen and Grabowski (1993) propose a transition from cognitive abilities to learning styles (See, Figure 1). Cognitive abilities covers the content and refers to the level of cognitive activity whereas styles indicate the manner and form of learning. According to the authors, abilities are stated in terms of maximal performance; therefore, they are unipolar (i.e., less ability...... more ability) and value directional measures (having more is better than having less), whereas styles are bipolar (visual....verbal) and value differentiated (neither pole is necessarily better). Jonassen and Grabowski (1993) conclude that abilities enable learners to perform tasks whereas styles control the ways in which tasks are performed.

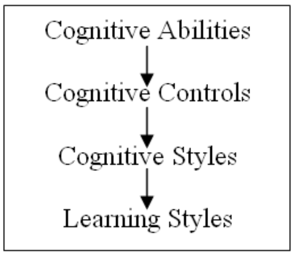

Figure 1. The relational transition of cognitive processes

To conclude, learning styles are less specific than cognitive styles, which are less specific than cognitive controls. Because learning styles are based on self-report measures, validity is one of the most articulated problems. Moreover, as speculated by some researchers, "...learning styles may not be legitimate research tools, ... they are useful methods for eliciting self-reflection and an understanding of the learning process" (Jonassen & Grabowski, 1993; p. 234). Therefore, this study utilized cognitive styles as a research tool, which defined cognitive processing characteristics based on task-relevant measures.

Field Dependent/Independent Cognitive Styles

There are various recognized cognitive styles available in the literature, among which are visual/haptic, visualizer/verbalizer, leveling/sharpening, serialist/holist, and field dependent/independent (See, Jonassen & Grabowski, 1993 for an extensive overview and the synthesis of related research).

Although various forms of cognitive styles have been introduced and different instruments have been developed to assess them, Witkin et al.'s (1971) Group Embedded Figures Test has been applied most commonly. There are two reasons for choosing GEFT in this study. First, the instrument is a non-verbal test and requires only a minimum level of language skill for performing the tasks (Cakan, 2003). Another reason is that psychometrical properties of the instrument have been investigated in cross-cultural settings and accepted as quite reasonable.

According to Witkin and Goodenough (1981), people are termed field independent (FI) if they are able to abstract an element from its context, or background field. In that case, they tend to be more analytic and approach problems in a more analytical way. Field dependent (FD) people, on the other hand, are more likely to be better at recalling social information such as conversation and relationships. They approach problems in a more global way by perceiving the total picture in a given context.

Daniels (1996) summarizes the general tendencies of field dependent and independent learners as follows:

Field-dependents:

- • Rely on the surrounding perceptual field.
- • Have difficulty attending to, extracting, and using non salient cues.
- • Have difficulty providing structure to ambiguous information.
- • Have difficulty restructuring new information and forging links with prior knowledge.
- • Have difficulty retrieving information from long-term memory.

Conversely, field-independents:

- • Perceive objects as separate from the field.
- • Can disembed relevant items from non-relevant items within the field.
- • Provide structure when it is not inherent in the presented information.
- • Reorganize information to provide a context for prior knowledge.
- • Tend to be more efficient at retrieving items from memory (p. 38)

In the following sections, research findings on cognitive field dependency, academic achievement, and attitude studies are discussed and synthesized.

Field Dependency and Academic Achievement

Cognitive style has been reported to be one of the significant factors that may impact students' achievement on various school subjects (see, Murphy, Casey, Day, & Young, 1997; Cakan, 2000). In a research study, Dwyer and Moore (1995) investigated the effect of cognitive style on achievement with 179 students who enrolled in an introductory education course at two universities in the United States. They found the field independent learners to be superior to field dependent learners on tests measuring different educational objectives. The researchers concluded that cognitive style had a significant association with students' academic achievement.

Tinajero and Paramo (1997) investigated the relationship between cognitive styles and student achievement in several subject domains (English, mathematics, natural science, social science, Spanish, and Galician). With the sample of 408 middle school students, the researchers asserted that cognitive style was a significant source of variation in overall performance of students. That is, field independent subjects outperformed their field dependent counterparts.

In another study, Murphy, Casey, Day, & Young (1997) sought to determine the relationship between academic achievement and cognitive style of 63 undergraduate Canadian students in information management program. They found that field independent students performed better than field dependent subjects only on one of the technical courses. For the other three courses the two groups performed similarly.

Although considereable research has been conducted on the impact of field dependence/ independence and academic achievement, the relationships between FD/FI cognitive style and learning, including the ability to learn from social environments (Summerville, 1999), and the impact of cognitive styles on the use of learning strategies (Jonassen, 1988; Liu & Reed, 1994), few studies have considered affective variables and cognitive styles together in teacher training programs.

Field Dependency and Attitude toward Computers

The studies investigating the correlations between attitudes toward computers and field dependency is limited area of research with contradictory results. In an earlier research study, Abouserie and Moss (1992) investigated 143 undergraduate freshman students' attitudes toward computer-assisted learning (CAL). They examined the relationship between students' attitude toward using CAL and their cognitive style (field dependent and field independent FD/FI) as they relate to gender. They found a significant correlation between students' attitudes and their field dependency. The findings showed that male students preferred using CAL more than female students did. In addition, FD students relied more on CAL than FI students did. This can be explained by FD students` tendency to prefer to learn specific and detailed information and use the existing organization of material as given instead of re-organizing it (Thompson, 1988, Witkin, Moore, Goodenough & Cox, 1977).

On the other hand, some researchers claim that no correlation exists between attitudes toward computers and cognitive styles (see, Hart, 1995). In a research study, Jones (1994) explored the existence of such a relationship with 140 undergraduate and graduate students by using the Myers-Briggs Type Indicator (MBTI). Jones (1994) found a small but insignificant correlations between the variables (between r = .-03 and r = .12).

In a more recent study, Altun (2003) also investigated the relationship between attitudes toward computers and cognitive styles by using Group Embedded Figures Test, with 67 undergraduate university students. The results indicated small but not significant correlations (between r= -.006 and r= .309) between these variables. Alomyan and Au (2004) conducted a research study with undergraduate university students to investigate the effect of students' cognitive styles, achievement motivation, prior knowledge, and attitudes on achievement in a web-based environment. In their findings, they have found no differences between students' attitudes toward web-based learning and their field dependencies.

One explanation for these contradictory findings in the literature may be that academic achievement has significant association with cognitive style (Murphy, Casey, Day, & Young, 1997; Tinajero and Paramo, 1997; Cakan, 2000, Dwyer and Moore, 2001). Therefore, academic achievement might intervene with and contribute to the relationship between cognitive style and attitudes toward computers.

Daniels (1996) examined cognitive style field dependence/independence based on the learner control of presentation mode within an educational hypermedia environment. Having problem-solving and recall rates as independent variables, he also explored the causal relationship between field dependency and the provision of control (i.e., program or learner) over presentation mode in hypermedia environments. He found no correlation between field dependency and frequency of multimedia selections, nor a predictive relationship between field dependency and selection of presentation mode. Daniels (1996) concludes that learner control of presentation mode does not offer any significant benefit to users of hypermedia, nor does it accommodate the perceptive and cognitive differences associated with the cognitive style field dependence/independence. Based on these findings, Daniels (1996) speculates that affective factors might have involved in the decision making process and confesses that examining the cognitive and affective variables that influence how learners interact in hypermedia environments may be more illuminating than post test measures of how much they learned.

To conclude, the construct of cognitive style has been treated as a promising variable which may explain differences observed among students' academic achievements on various subjects and provide us a better understanding of student achievement by investigating the interactional and casual effects of affective variables. The current findings would help instructional designers and practitioners develop better quality instructional delivery methods, another component to consider when designing web-based learning environments. Moreover, the findings might prove more solid theoretical understanding of the cognitive issues from the standpoint of cognitive styles and attitudes toward computers.

Research Hypothesis

H1. There will be no significant relationship between cognitive style scores and achievement scores of the participants.
H2. There will be no significant relationship between cognitive style scores and attitude scores toward computers.
H3. There will be no difference between attitude scores of the field dependent and field independent students when the effect of achievement scores is removed.

Research Method

Design and Participants

This study undertook a correlation design to explore the hypotheses. Due to the nature of correlational research, no causal relationship is sought. The design tells us about the bivariate relations between the variables. This limits the findings as to speculate about the existence of any cause and effect relationship between field dependency and attitudes.

The sample of the study consisted of 130 undergraduate students ranging from freshman to senior levels at a teacher training program at Abant Izzet Baysal University in Turkey. The program aims at training English language teachers for primary and secondary level schools after their four-year of study. The first and second year mainly focuses on developing trainees' English language and basic computer skills (such as, speaking, writing, listening, computer operations, and reading skills). Starting from the third year, teacher training courses (i.e., classroom management, methods, lesson plans etc.) are provided. The last year of the program emphasizes the practicum approach in school settings; where trainees are taken to schools to (co) teach lessons and understand the daily routines at schools. The participants in the study were 22 males (16.9 %) and 108 females (83.1 %). This imbalance between genders may be attributed to the occupational preference of females in Turkey. This study, therefore, is limited to the data from predominantly female students.

Instruments

The Group Embedded Figures Test (GEFT)

Therefore, the Group Embedded Figures Test (Witkin et al. 1971) was used to determine the participants' cognitive styles. The instrument has been translated and validated into Turkish by Cakan (2003). The test consisted of 3 sections. The first section was given for practice purposes and included 7 items. Both the second and third sections contained 9 items. The total time for completing the test was 12 minutes. The instrument required each individual to trace a specified simple figure that was embedded within a complex design. A subject's total score was formed by a number of simple figures correctly traced in section 2 and 3 of the test. The possible score that one could make ranged from 0 to 18. Although Witkin et al. (1971) do not specify a clear cut off score for determining field dependent and independent individuals, the 27% rule created by Cureton (1957) is applied for classification purposes. Thus, based on the raw scores of the subjects on the GEFT, upper 27 % are identified as field independent (FI) and the lower 27 % as field dependent (FD). During the administration of the GEFT, the exact procedures set out in the technical manual (Witkin, et al., 1971) regarding time limits and directions were closely followed.

Computer Attitude Scale (CAS)

The computer attitude scale (CAS), originally developed by Loyd and Gressard (1984), was used in this study. CAS is a Likert-type instrument consisting of 30 items in three dimensions: computer anxiety (10 items); computer liking (10 items); and, computer confidence in ability to use computers (10 items). The coefficient alpha reliabilities were .75, .70, and .73 for the subscales respectively with accounting 53 % of the total variation. The total score reliability was also reported to be .89. Since the participants were proficient enough to understand the English statements, the items were not translated into Turkish.

Background Questionnaire

In addition to GEFT and CAS, the participants were asked to complete a form which included some moderating variables, such as gender, grade level, the number of computer courses taken, and ownership of a computer. This information was used both to display general demographic information and to be moderating variables. These moderating variables are also considered to be a kind of independent variable with a possible significant contributory effect on the independent-dependent relationship.

Data collection procedure

The data was collected during the fall term of 2001-2003. At the end of the fall semester, participants were asked to participate in this study on a volunteer base. The students were first administered the cognitive style test. After a week, they were administered the computer attitude scale with the background questionnaire. Also, students' GPA scores were obtained from school records.

Statistical Techniques

Pearson's product moment correlation coefficient was used to determine if the correlation is either equal or not equal to zero by using the 5 % significant level of committing a Type I error. A correlation analysis and the analysis of covariance (ANCOVA) procedures were used to analyze data. The ANCOVA procedure was used to remove the potential sources of variations from various achievement levels. In order to check that the assumption of equality of variance was not violated, Levene's Test of Equality of Error Variances was calculated.

In this study, participants' achievement scores were chosen as covariate when attitude score differences were investigated depending upon the cognitive styles. For testing hypothesis 2, grade level is included because it may have a significant contributory or contingent effect on the correlation between attitude toward computers and cognitive style.

Results

Figure 2 displays the descriptive statistics for participants' cognitive styles and grade levels.

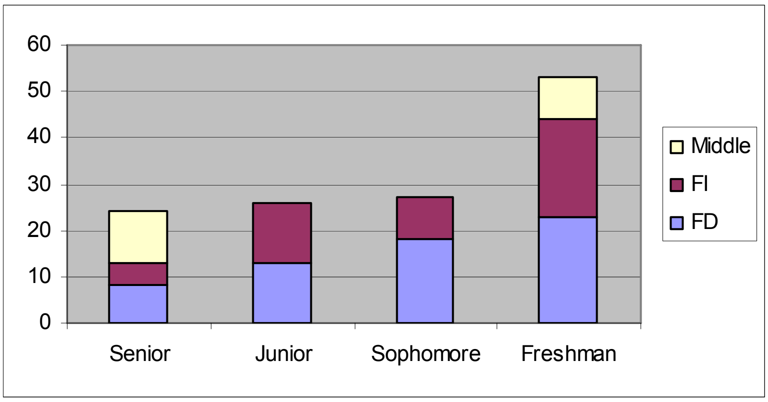

Figure 2. Participants and their cognitive styles

As Figure 2 indicates, more than a half of the participants were field dependent (% 47.7). Of the participants, 36.9 % were field independent whereas % 15.4 of them were in the middle group meaning that they did not have certain tendency to either pole of the style.

Cognitive Styles and Achievement Scores

A correlation analysis was conducted to test the first hypothesis. Contrary to expectations, the results revealed insignificant correlation between participants' academic achievement and their cognitive styles ($r = .14, p= .15$). The results suggested that cognitive style had insignificant relationship with the participants' achievement scores. In other words, participants' cognitive styles did not depend on their achievement scores.

This result did not support the previous studies which emphasized an association between the type of cognitive style and academic achievement (i.e., Dwyer and Moore, 2001). This may be due to the variation in the course subjects that students had taken from the first year through the fourth year and/or instructors' teaching preferences in those classes.

Cognitive Styles and Attitudes

The result of the correlation analysis between cognitive style scores and attitude scores toward computer revealed a negative correlation close to zero level ($r = .01$, $p = .84$). Correlation between cognitive style and attitude scores by grade levels were presented in Table 1.

*Table .1*Correlation between cognitive style and attitude scores across grades

	N	r	p
Freshman	53	-.005	.97
Sophomore	27	.35	.07
Junior	26	.009	.97
Senior	24	.20	.37
Overall	130	.14	.15

As seen from the table, cognitive style has a negative and low relationship with attitude scores for the first year students. Attitude has the greatest correlation value for sophomores. This may simply due the fact that computer literacy course is offered at the sophomore level. Yet, this correlation is not significant. Overall, the association between cognitive styles and attitudes do not change among participants as their grade levels change.

Table 2 displays the correlations between GEFT scores and three subgroups in the attitude scale across gender. There are some positive and negative correlations between subgroups; however, most of them were found to be significant. Male students' GEFT scores were found to be significantly correlated with their attitudes at the anxiety subgroup. To put it another way, males get more anxious across cognitive styles whereas females do not differ in both cognitive styles.

*Table 2.*Correlation between cognitive style and attitude subgroup scores across gender

	Male (n= 22)		Female (n= 83)		Overall (n= 130)	
	r	p	r	p	r	p
Liking	.40	.07	-.07	.49	- .02	.87
Confidence	.33	.14	-.05	.60	.04	.65
Anxiety	- .01	.009*	- .02	.84	- .04	.65

* p < .05

Cognitive Styles and Attitudes: Academic achievement as a covariate

In order to test the hypothesis an ANCOVA (attitude scores by cognitive style groups while GPA is taken as a covariate variable) was applied. Achievement scores of the students were used as a covariate to test the difference between FD and FI participants' computer attitude scores. After adjusting achievement scores, there was no significant effect of the between subjects cognitive style groups ($F(2,126) = .40$, $p< .05$). The finding reveal that even when we remove the effect of GPA on attitude scores, field dependent and independent students demonstrate similar attitudes toward computers ($F = .62$; $p = .43$).

This finding suggests that students' attitudes toward computers are not associated with cognitive style, even when their achievement levels were controlled. Attitude toward computers is found to function independently from cognitive styles.

Conclusions

Earlier research suggested a significant association between cognitive styles and academic achievement (Dwyer and Moore, 2001; Lynch, Woelfl, Hanssen & Steele, 1998). Yet, unlike previous studies, this study revealed no significant association between academic achievement of the students and their cognitive styles. Prior studies (Witkin, Moore, Goodenough & Cox, 1977; Cakan, 2000) have shown that field-independent and field-dependent students do not differ in learning ability but may respond differently to the content being presented as well as the learning environment. Therefore, this result may be due to variation in the contents of courses students took from their first year through the fourth year. Another reason can simply be the fact that the participants in this study included females predominantly, and there were no one in the middle cognitive style group. This distribution might have led this conclusion.

In the current study, students' GPAs included all their courses across all grade levels. Regardless of grade level, students' attitudes toward computers seem to be independent of cognitive style. As far as gender is considered, the only significant correlation between GEFT scores and attitudes was at the anxiety level. Yet, the number of male participants was considerably low for correlational studies. Therefore, this may not be valid if more male participants were included. These findings are consistent with previous studies (Abouserie & Moss, 1992; Altun, 2003). Moreover, no significant relationship was observed between males and females. Both female and male teacher trainees are inclined to using computers regardless of their grade level or gender.

Even when the effect of achievement was removed from students' attitude scores toward computers, attitude scores was not related to the cognitive style scores of the students. When dealing with student attitudes toward computer use, educators do not need to take the cognitive style of the students into account. This gives freedom to educators to act without concerning cognitive style variables in the process of understanding and dealing with the affective domain.

Recommendations for future research

A number of limitations need to be considered in interpreting the findings of this study. First, this study included only the students from the department of English Language Teaching. A more comprehensive study including the other disciplines and /or across disciplines will contribute to our understanding of the relationship between cognitive styles and attitudes as well as their main effect on achievement. It is possible that a different type of training program would yield different results. Secondly, this study predominantly included female students. Another study with a more gender-equal sample is encouraged. As with any scientific finding, replication is needed in different settings with diverse populations to increase the external validity. It also needs to be emphasized that this study used only Witkin et. al.'s (1971) FD/FI as an indicator of cognitive style. Other cognitive style inventories could be applied to explore the interrelationship between academic achievement and attitudes in a broader context. Finally, this study did not include any data about participants' self-reflections about their learning preferences. Therefore, this study can be extended to further explore the associations between learning styles and attitudes from a qualitative paradigm.

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Identifying and measuring individual engagement in critical thinking in online discussions: An exploratory case study

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ABSTRACT

This paper reports on an exploratory case study involving the development of a model for identifying and measuring individual engagement in critical thinking in an online asynchronous discussion (OAD). The model is first developed through a review of the literature on the construct and subsequently applied to the content analysis of the transcripts of eight student participants in an online discussion. The model, which included four critical thinking processes, their descriptions and indicators, proved effective for the identification and measurement of individuals' critical thinking in OADs. Suggestions for further research include additional testing of the model using other raters in other OADs.

Keywords

Content analysis, Critical thinking, Online asynchronous discussion, Distance learning

Introduction

In spite of their increasing prominence and potential value, the extent to which online asynchronous discussions contribute to learning has not yet been clearly determined. As Bullen (1998) concluded, there is Alimited empirical support ... for the claims made about the potential of computer conferencing to facilitate higher level thinking@ (p. 7). Likewise, Garrison, Anderson and Archer (2000) argue that, in spite of the perceived potential of computer-mediated communication and computer conferencing, their effects on learning and its outcomes have not yet been well investigated. Not surprisingly, according to Gunawardena, Lowe and Anderson (1997), the use of computer conferencing and online discussions has A...outstripped the development of theory@ creating a need to determine ways of evaluating the quality of interactions and of learning in such contexts (p. 397).

The contribution that online discussions might make to the promotion of critical thinking skills is one example of the types of investigations that might be pursued in order to further our understanding of the role of these technologies in promoting learning. Critical thinking skills are often cited as aims or outcomes of education and Oliver (2001) argues that critical thinking skills represent an important issue for universities. While engagement in a cognitive process such as critical thinking in an online asynchronous discussion in a university course may be a desired outcome from both the instructor=s and students' perspective, it is unclear exactly how we might determine if such engagement actually occurs.

Although some aspects of critical thinking in online asynchronous discussions have been investigated (e.g. Angeli, Valanides & Bonk, 2003; Khine, Yeap, & Lok, 2003), few studies focus specifically on critical thinking, and few focus on reporting individual engagement. More typically, aggregate measures of group engagement in general are reported instead. Another problematic aspect of previous studies of content analysis of online discussion involving critical thinking is that the instruments are often too cumbersome for use by instructors or students wanting to measure or identify engagement in critical thinking. According to Henri (1992), A...if content analysis is to become a workable tool for educators who are not trained as scientists, progress must be made at the conceptual level...and at the technical level...@ (p. 134).

The purpose of the study reported on in this paper was to provide a model that might be used by instructors or students to identify and measure engagement in critical thinking in the context of online discussions. The model aims to promote construct validity by developing its related processes through a critical analysis and evaluation of the literature on the construct. The model is then applied to the analysis of the transcripts of eight students participating in an online graduate course. The paper begins with a description of how the model was developed. The description is followed by an outline of the study's methodology. The findings are presented in such a way as to facilitate comparisons between participants in terms of their critical thinking behaviours. Implications for practice and research are presented.

Development of a model

Identifying the Processes

Table 1 summarizes the main processes identified from the literature, showing similarities and differences in approaches to defining the construct of critical thinking. Most of these include five steps: elementary clarification, elementary and advanced/in depth clarification, inference, judgement and strategies or tactics. Different authors have combined the same basic processes in different ways in order to facilitate analysis. The following table contains lists of the critical thinking processes identified by selected earlier authors, shown as steps followed by critical thinkers.

*Table 1***.** Summary of Critical Thinking Models

Authors	Norris & Ennis (1989)	Henri (1992) Clulow & Brace-Govan (2001)	Garrison, Anderson & Archer (2001)	Newman, Webb & Cochrane (1995)	Bullen (1997)
Step 1	elementary clarification	elementary clar-ification	triggering events	clarification	clarification
Step 2	basic support	in-depth clarification	exploration	in-depth clarification	assessing evidence
Step 3	inference	inference	provisional	inference	Making and judging inferences
Step 4	advanced clarification	judgement	resolution	judgement	Using appropriate strategies and tactics
Step 5	strategies and tactics	strategies	C	strategy formation	C

Several considerations, such as theoretical compatibility and practicality, must be weighed in making the selection of the critical thinking processes to be included in a model of critical thinking. For example, the easiest approach to the selection of critical thinking processes would be to simply choose a list of processes from the literature. However, this approach may not be feasible if the processes are derived from and organised by a method aiming to assess groups as opposed to individuals. The Community of Inquiry model (see Archer, Garrison, Anderson & Rourke, 2001; Garrison, Anderson & Archer, 2001) focus on Acritical thinking within a group dynamic as reflected by the perspective of a community of enquiry@ (Garrison, Anderson & Archer, 2001, p. 11). This focus on the group dynamic is pertinent when the goal is to examine evidence of critical thinking in the online community as a whole; however, this approach would not be relevant in cases where the focus is on the individual member of the online community.

The other researchers listed in Table 1 all give comparable lists of processes. They all cite clarification, making inferences, and strategies, and make some reference to providing and assessing evidence. How exactly these processes are organized B for example, is >clarification= a single group of processes, or split into two B depends on the needs of the researchers, who adapt earlier approaches to identifying critical thinking to their present purposes (see, Bullen, 1997 pp. 93-94).

The list of critical thinking processes adopted for the study's model were influenced by many researchers (Bullen, 1997, 1998; Clulow & Brace-Govan, 2001; Garrison, Anderson & Archer, 2001; Henri, 1992; Newman, Webb & Cochrane, 1995; Norris & Ennis, 1989). These were examined with the aim of creating as short, yet complete, a list of processes as possible. For example, Garrison, Anderson and Archer (in press) describe a triggering event which is the initial phase of critical enquiry when "an issue, dilemma or problem that emerges from experience is identified or recognised". This triggering event was eliminated, partly because the holistic approach of that model makes it difficult to apply to individual transcripts from an online asynchronous discussion structured and limited by the time and subject matter requirements of a course. In addition, to use one example of a triggering event indicator, the equivalent of the >sense of puzzlement= (Garrison, Anderson & Archer, 2000) in a course transcript, would be the topic suggested by either the instructor or a student. In a model designed for simplicity and ease of use, the initial question or triggering event can easily be included as part of clarification, which is described as >Observing or studying a problem= by Henri (1992) or >Focussing on a question= by Norris and Ennis (1989).

Upon examining the approaches in Table 1, another modification was judged as both reasonable and useful in developing a model that can be used as a basis for assessing individual=s engagement in critical thinking in an OAD. This modification consisted of combining elementary and advanced or in-depth clarification into one category, as they are similar, following the precedent set by Bullen (1997). This approach would lead to a model consisting of four categories or processes as follows: clarification, assessing evidence, inference, and strategies. The single clarification category includes Norris and Ennis' (1989) elementary clarification, and some parts of their advanced clarification B those parts dealing with defining of terms and identifying assumptions. The clarification category of this model does not include those parts of Norris and Ennis' (1989) elementary clarification dealing with judgements. In this model, judgements are part of the assessment category. >Clarification= in this model is similar to a combination of Henri's (1992) elementary and in-depth clarification, and also to Bullen=s (1997) clarification.

Although, in many respects, the model presented in this paper is similar to Bullen=s (1997), there is one major difference. Bullen (1997) uses >strategies= to refer to thinking strategies, such as using algorithms, models, and changing focus (looking at the big picture). Other researchers tend to consider 'strategies' to refer to taking action as a result of thinking critically about a problem or issue. Garrison, Anderson and Archer (in press) write of a Aresolution ... by means of direct or vicarious action@ (p. 2); Newman, Webb and Cochrane (1995) use strategy formation, which they describe as AProposing co-ordinated actions for the application of a solution, or following through on a choice or decision@ (Evaluating critical thinking, para 8). In this study, >Strategies= will be understood as a plan for action and not a way to analyse the problem.

These differences are a result of the process of drawing on the earlier models to create one that can easily be used to support the coding of transcripts of an online asynchronous discussion. For simplicity and ease of use, the number of processes has been reduced to four, and the understanding of the processes >strategies= and >judgement= or >assessment= modified. The four processes begin with clarification which includes everything involved in proposing, describing and defining the issue. Next is assessment, which covers various types of judgements, including the use of evidence to support or refute a judgement. The third process is inference, which covers thinking skills B not only induction and deduction, but generalizing as well. Finally, the fourth process, strategies, does not refer to tactics such as the use of algorithms or models, but to practical proposals for dealing with the issue under discussion. Clearly, this model leaves out much of the wealth of knowledge of critical thinking. However, a model which identified critical thinking processes in more detail would be less suited to the task of providing a comparatively simple way to assess critical thinking of individuals in an OAD used as part of a course.

In order to move from a critical thinking model to the analysis of a transcript, further delineation of the model is necessary. Following the addition of descriptions for each critical thinking process, this delineation may be provided by lists of indicators associated with the critical thinking processes. Indicators are sometimes referred to by other names; for example, Norris and Ennis (1989) write about >topics=. Whatever term is used, indicators provide further insight into the different critical thinking processes. They help clarify in the minds of the users of the model which types of thinking belong in each critical thinking category.

Identifying the Indicators

Critical thinking processes are broad enough that a very long list of indicators could be written to represent each of them. It is necessary to provide a list of indicators that captures the essence of the particular critical thinking process in question without being excessively long and complicated to use when applying the model to the analysis of a transcript of an OAD. To ensure discriminate capability, each indicator should refer to only one aspect of a critical thinking process, and no two indicators should refer to the same aspect of critical thinking. In addition, the indicators, taken together, should cover all the aspects of critical thinking processes to avoid construct under-representation without being so numerous as to make applying the final model too time-consuming and cumbersome.

The choice of the model's indicators can be illustrated with the following example. One of the critical thinking processes is clarification: seeking and expressing understanding of the topic in question. Clearly, clarification includes a wide range of actions. A first step in choosing an indicator is to examine previous work to determine what approaches have already been used to create an indicator for this aspect of clarification. One of the most basic aspects of clarification is identifying or stating an issue. Table 2 provides the results of this examination for this example.

Table 2. An Example of Choosing and Writing Critical Thinking Indicators

Study	Indicator
Norris & Ennis (1989)	Seek a statement of the thesis or question
Henri (1992)	Identifying relevant elements
Garrison, Anderson & Archer (2001)	Recognizing the problem
Newman, Webb & Cochrane (1995)	Course related problems brought in
Bullen (1997)	Focusing on a question a) Identifying or formulating a question

Deciding on the exact wording of an indicator is influenced by the context in which it will be used. For example, the study reported on in this paper focused on a course in which issues, many of them identified by the students, are to be discussed. >Seek= (Norris & Ennis, 1989) is too broad in this context. >Identifying= (Henri, 1992) and >recognizing= (Garrison, Anderson & Archer, 2001) are not appropriate for an OAD in a course for which participants are expected to suggest topics for debate. Newman, Webb and Cochrane=s (1995) wording is close, but they add other indicators to cover the possibility that the topic of discussion or problem may arise outside the course. Bullen=s (1997) version is too lengthy to be practical. After examining the relevant indicators from the literature, the term 'proposes= was chosen as the appropriate verb. It includes both the idea of identifying or seeking a topic, as used by other researchers, but also includes the idea that the topic is to be presented to a group for discussion. This makes >proposes= a suitable choice for a model intended for use with an OAD. >Problems=, as used in some of the examples from the literature, was avoided in favour of >issues= because >problems= might imply that problem-solving was being identified and measured. The other indicators were added following the same procedure. Table 3 presents the final model with the indicators added to each of the four categories. The model also includes a description of each process.

Table 3. Model for identifying engagement in critical thinking

CLARIFICATION				
All aspects of stating, clarifying, describing (but not explaining) or defining the issue being discussed.				
Proposes an issue for debate.	Analyses, negotiates or discusses the meaning of the issue.	Identifies one or more underlying assumptions in a statement in the discussion.	Identifies relationships among the statements or assumptions.	Defines or criticizes the definition of relevant terms.
ASSESSMENT				
Evaluating some aspect of the debate; making judgments on a situation, proposing evidence for an argument or for links with other issues.				
Provides or asks for reasons that proffered evidence is valid.	Provides or asks for reasons that proffered evidence is relevant.	Specifies assessment criteria, such as the credibility of the source.	Makes a value judgment on the assessment criteria or a situation or topic.	Gives evidence for choice of assessment criteria.
INFERENCE				
Showing connections among ideas; drawing appropriate conclusions by deduction or induction, generalizing, explaining (but not describing), and hypothesizing.				
Makes appropriate deductions.	Makes appropriate inferences.	Arrives at a conclusion.	Makes generalizations	Deduces relationships among ideas.
STRATEGIES				
Proposing, discussing, or evaluating possible actions.				
Takes action.	Describes possible actions.	Evaluates possible actions.	Predicts outcomes of proposed actions.	

Methodology

The OAD transcripts used in this study were obtained from two different sections of a web-based, graduate course in Education during the Fall, 2002 and Spring, 2003 semesters. Information on the course, obtained from the course web site with permission of the instructor, showed that the two sections of the course were the same. Twenty percent of the final course grade was assigned to students= participation in the OAD. The grading rubric indicates that students were expected to demonstrate many aspects of critical thinking in their posts. For example, for a score of 18-20, students would be expected to write postings that A...reflect a superior level of insight, originality, analysis and critical thinking...@. Twelve of the thirty-five students in the two sections of the course responded to an email request for volunteers to participate in the study. Some participants who responded to the original email request were not included in the study for various reasons, including no or delayed return of the signed consent form, and extremely brief or atypical postings. Of the twelve people who had responded to the original call for volunteers, eight were included in the study.

The application of the model involved reading transcripts, marking passages representing a unit of meaning and coding each passage. Two approaches to coding were tried during the application: one was to code the units of meaning by indicator, and then cluster the indicators according to the critical thinking process. The second was to use the indicators as guides, but code each unit of meaning according to the appropriate critical thinking process directly. This second procedure proved most effective and was adopted for the application of the model. In some cases, more than one critical thinking process appeared within a given passage, and the passage was coded as demonstrating the process that appeared most important in that context. Therefore, only one code was used for each unit of meaning.

Although all of the transcripts selected for the study were coded, not all text in all transcripts received a code. Most of the text that was not included was material of a personal or social nature, such as the personal introductions at the beginning of the course. While important for creating a sense of community among the online students, these passages were clearly not part of the discussion and analysis of issues which the course was intended to address, and which were expected to produce examples of critical thinking. Finally, posts looking for partners for group work or taking care of other such practical details were not included in the analysis, for the same reasons that the personal introductions were omitted.

Findings

Table 4 presents a summary of individual participants' engagement in critical thinking which was derived by coding each of their transcripts using the model presented in an earlier section of this paper. Individual participants' engagement is discussed and selected examples for each critical thinking process are presented.

Table 4. Numerical summary of participants' engagement in critical thinking

	Participants								
	A	B	C	D	E	F	G	H	Mean
Total # of messages	79	27	27	87	39	49	19	25	47
Total # of coded units	61	34	28	63	53	35	19	27	46
% of units coded as Clarification	41	29	46	51	26	28	37	37	42
% of units coded as Assessment	16	35	40	9	34	57	5	37	33
% of units coded as Inference	20	15	11	16	21	9	48	19	23
% of units coded as Strategies	23	21	3	24	19	6	10	7	16

As is evidenced by the results in the table, the group as a whole tended to engage more in clarification and less in strategies than in the three other processes. In general, participants tended to engage less in strategy-related behaviours with a mean percentage of 16% of the units coded for this process. In contrast, participants tended to engage more in clarification-related behaviours with a mean percentage of 42% of the units coded for this process. Comparisons between participants highlight individual differences and preferences for engagement in particular processes related to critical thinking.

At the individual level, beginning with Participant A, we can observe that this individual engaged more frequently in clarification than in other processes. He also posted the second highest number of messages as compared to other participants. This individual begins by proposing filtering as an issue for debate or discussion and by distinguishing it from a similar activity: AFiltering software was seen as a proactive measure, whereas simple monitoring could only ever be reactive@. He also used critical thinking processes other than clarification. In the following example, he makes a value judgement or assessment of his co-workers in education, as opposed to those in other professions: “It's one of the things that I like best about the teaching profession - that for the most part the people I work with are generous and willing to help their colleagues in any way they can.”

Participant A also engages in inference when he notes the similarities and differences between classroom and online asynchronous discussions with the following conclusion: “Discussion would be different because it would be less reflective, but more spontaneous.” Compared to others in the group, he exhibits above-average engagement in strategy-related behaviours. In the following passage, he describes ways to deal with problems that arise when students are searching online. He also predicts the outcomes of this activity based on his experience:

> Even when every student is doing research on a different topic they have chosen themselves, there is still a way to limit that type of accident. Before letting them go wild in Google, I get them to write their search string on a piece of note paper and show it to me. It lets me see what they might see and gives me a chance to help refine their searching techniques.

Like Participant A, Participant B engaged more in clarification than in inferring. His engagement in this process was average compared to others while his engagement in clarification was less than average. He demonstrates assessment by briefly evaluating the results of an attempt to solve a problem by administering a mathematics skills test in school: AHowever, preliminary findings have shown little increase in their skills after the MST@. He follows this assessment of the results by suggesting a strategy: ”I am looking towards interactive computer software that students could use outside of class time@. In the following passage, he shows evidence of inferring by arriving at a conclusion and hypothesizing and showing the connections between the Universities= assessment of constructivism in mathematics instruction, and teachers= classroom practices, particularly those involving the use of technology in mathematics instruction:

> In a few years’ time when the universities claim that the constructivism approach to mathematics was a failure … they will be right. Especially if something is not done to encourage math teachers to use technology so that students can construct their own meaning of the concepts.

Of note in the transcript of Participant C is that the last critical thinking process, strategies, was not one he used extensively. But he did suggest one strategy as follows:

> Why don't we create our own digital repository [?] If anyone in the class has resources that they have gathered or created, and posted to their own web sites, please send me the URL, and a short description of the subject areas to which they apply.

Had the individual made more postings, he might have exhibited more examples of engagement in strategies. This individual only had 28 coded units which was below the mean of 46 and well below the number of coded units for Participant A. Of the postings made, more units were coded for clarifying and assessing than for other processes. The following example is illustrative of how individuals can engage in inferring by presenting a conclusion along with supporting arguments:

> … collaboration is necessary because we can all learn from each other … Even with tremendous dedication of time, and effort, we can only come up with so much on our own, and what we do learn throughout the solitary process will be influenced by our earliest exposure to topics, as well as our own limitations of preference, and ability. Collaboration allows us a process to circumvent these limitations.

Coding of the transcript of Participant D showed how her engagement in critical thinking was different from that of the others in her group. While her transcript produced almost the same number of coded units at Participant A, her use of the various processes was different from his, and from that of other participants. For example, she had the highest percentage of units coded as clarification as well as the highest percentage coded for strategies. She also had the highest number of coded units compared to all others. Interestingly, in terms of assessment and inferring, she had a below average number of coded units. Compared to the other participants, her engagement in critical thinking is most similar to that of Participant A. Although she does not frequently engage in assessing, this one example provides clear indicators of the process: AAfter researching and completing the trend of integration of computers in classrooms, my only conclusion is that the majority of barriers could be eliminated with an influx of money.@ In terms of units coded as strategies B in other words, describing, proposing or evaluating possible outcomes or actions, she wrote an extensive description of ways in which a class web site can be used to address numerous educational problems such as forgotten texts, homework, or handouts, access to missed work for sick or failing students, and access to an email link for students who are away from class and need to submit work.

Except for the lower levels of engagement in clarification as compared to the others in the group, Participant E’s engagement in all other processes is average. He enters into the discussion by engaging in clarification and proposing an issue for debate as follows: AIs the use of technology in our schools changing the relationship among teachers, students and parents?@ He then goes on to assess and judge this issue by focusing the discussion on the meaning of terms:

> I also wonder what we mean when we say 'value'. In my school, each teacher has a networked computer on the desk. All teachers use it for attendance, and …. I think we now value computer technology for these uses. However, if I asked my colleagues how many of them used these computers with their students, I suspect the answer would be …. Is this also an issue of 'value'?

In the following example, he draws conclusions and states hypotheses: “If it is through this negotiation that we construct our knowledge, then we need to build negotiation into the process.” The next excerpt from his transcript provides a clear example of a unit coded as strategy: “I am going to use LOs every chance that I get! … Some of them just present similar information but in different ways, so they will help me cater to various learning styles.”

The transcript of Participant F presents the highest percentage of units coded as assessment compared to other participants. As well, of note in the transcript is a low level of engagement in both inference and strategies with only 9% and 6% respectively. An example of her engagement in clarification can be found in a message in which she proposes an issue related to grading online discussions: “One point I wanted to raise about online discussion is the motivation when marks are involved. … Sure, assigning a grade encourages students to post, but to what end?” An example of her engagement in assessment is evident in her valuing of one form of discussion over another: “For me, this mode of discussion and expression of views appears to have many benefits over classroom discussion.” There were few instances of engagement in inference and strategies; however, one example might be found when she draws conclusions and makes generalizations about technology use as follows: AI agree that the way in which technology is being used can be responsible for the loss of certain basic skills.@ In terms of strategies, she proposes a solution to the problem of the lack of teacher training in technology in the following segment: A…perhaps a web site which combines tutorials with a technology question forum as you have suggested might be a welcome addition.@

The analysis of Participant G’s transcript revealed very low engagement in assessment compared to the other participants and the other processes. At the same time, coding also revealed the highest engagement in inference compared to all other participants. Like others, this participant did not often propose actions or strategies. His use of clarification is evident in the following passage in which he describes his interest in the issue of access to computers for the disabled: “As I expect to become involved in designing online learning in the near future, I would like to learn how to make online content accessible to all individuals, including those with disabilities”. An example of engagement in assessment is as follows: APersonally I have found sharing to be very easy in my work, perhaps because I have only had positive sharing experiences.@ One of the many examples in his transcript coded as inference and drawing conclusions is as follows: ASharing with others also promotes positive relations in the school community, which can help make the school a more comfortable and ’easier‘ place to be”. An example of strategies is evident in the following proposal: “To promote interactive discussion, respondents could be required to make one original criticism (in addition to any original praise).”

Of note in the coding of the transcript of Participant H was the equal emphasis placed on clarification and assessment and the low engagement in strategies. In terms of clarification, she provides an example of a unit that might be coded as this process in this excerpt from her transcript: AAs to Internet Plagiarism, I think it's not only found in Educational field and it should not only point to students.” In terms of assessment, one example of a unit coded for this process is as follows: AAll these were running well via the medium of web, which I think offer a good opportunity for us to share work and exchange ideas anytime anywhere. I really enjoy this kind of teaching and learning.@ The following example illustrates engagement in inference by showing connections, generalizing and explaining:

> …I think information is more like a carrier for knowledge. … Information could be any piece of mental or mental-based visual, audial (sic) existence or abstract thoughts. While knowledge would be a

systematic information collection. We collect and digest information and then construct our own knowledge.

Discussion

The purpose of the study was to provide a model of critical thinking that could be used efficiently and easily to derive and present individual profiles of engagement in critical thinking. The profiles presented above give only limited insight in terms of individual profiles. However, without the limitations of length of a paper, more information could be generated on each participant using the model to code their transcripts. The numerical summary presented at the beginning of the findings highlights similarities and differences between participants. With a larger group, the comparison might be more revealing in terms of showing patterns of behaviours. Nonetheless, even with the limited size of the group, comparisons could be made. The brief descriptions provided for each participant provide insight into how the processes and indicators can be matched with behaviours evident in the transcripts. The examples also highlight the different ways that the behaviours can manifest themselves.

The coding using the model made evident differences in behaviour that might be useful in a variety of ways. The instructor may be planning to engage students in particular behaviours within the realm of critical thinking. For example, a successful outcome in the context of a particular course might be to be able to propose an issue for debate, evaluate and make judgements related to the issues, subsequently pose hypotheses, generalizations or conclusion and finally suggest actions or strategies that might be taken or adopted. Using a model such as the one proposed in this paper provides a means to direct such behaviour by outlining the indicators and types of associated behaviour. It also provides a means to verify that individuals actually did engage in all the required behaviours. Analyses of each participant's transcript might be completed by the students and he or she required to submit examples of engagement in these processes in the course of the discussion. In this regard the model could be provided to students to guide their behaviour formatively and to assess it summatively.

Other useful insights can be derived from these results. There were clear differences in the proportions among the critical thinking processes for the different students. Since all students were in the same course, and most of them in the same OAD, the differences in the critical thinking processes in which they engaged may reflect differences in the processes that the student is comfortable with, or even capable of using. Knowing this, the instructor may decide to revise the course to encourage a broader range of processes, or provide feedback to students who appear to be uncomfortable with or unable to engage in a particular critical thinking process. The model may as well prove useful for designers and instructors interested in structuring or moderating the discussion. It could be used to focus on developing teaching strategies or to encourage specific types of critical thinking processes. If, for example, the goal is for the students to engage in inference more often, and clarification less often, the model can help direct engagement in one or the other.

Conclusions and Further Research

The results of the application of the model showed that it could be used to obtain insight into the critical thinking processes used by participants in an OAD. This process could be applied to other thinking skills, such as problem-solving or knowledge construction. The need for such work has been identified in the literature (see Henri, 1992; Rourke, Anderson, Garrison & Archer, 2001; Zhu, 1996). The greatest challenge in any study using the approach of this one is undoubtedly creating and selecting indicators, which are essential to promoting construct validity of the model and its ability to adequately represent the construct in question.

This study was limited to coding by only one rater, therefore no tests of reliability were conducted. Although there are some indications in the literature that inter-rater reliability is acceptable in rating online discussion transcripts (see MacKinnon, 2003), further work would be useful in confirming or contradicting this. Future studies might make use of the model with other raters, in different courses, in other contexts and with more participants.

Possibly, the proportions of the critical thinking processes observed may be affected by the requirements of the course as well as the personal variations among the students. This is only one hypothesis that could be tested by expanding the application of the model into a wider range of OADs from different courses. Such expanded application could also be used to find evidence as to whether there are subject-specific critical thinking processes, and if there are, what processes and indicators should be added to the model. Some research in this area would include measuring uncritical, as well as critical thinking, in order to give a better and more balanced picture of an individual=s thinking. Adding this dimension to the model and testing it would be another avenue for further research.

Both instructors and students could benefit from using the model developed in this study. Instructors who have designed their OAD to encourage the use of critical thinking processes can rate their students' transcripts using the model in order to assess the success of their efforts to encourage critical thinking. They can also focus on developing teaching strategies to encourage specific types of critical thinking processes if, for example, they want the students to use inference more often, and clarification less often. Applying the model to their students' transcripts will reveal which critical thinking processes are most frequently engaged in. This is information that instructors need before deciding which specific skills to encourage or before determining how successful their efforts were in supporting particular skills.

The model could also be used as the basis of a student evaluation tool. It would also be relatively simple to modify the model into a rubric by assigning marks to each critical thinking process and adjusting the rating system somewhat. In other words, it would be necessary to rework the model from one intending to provide feedback on a personal level to one specifically designed to compare and rate students' performances.

Students could also use this model, in their case, for self-assessment. Self-assessment might be required by the instructor as part of the course work or course evaluation. Some students may wish to use it for their own personal benefit, to enhance their understanding of the cognitive processes involved in critical thinking, or to monitor and enhance their own contributions to an OAD.

In conclusion, this study, although small scale and preliminary in nature, demonstrates the potential usefulness and importance of identifying critical thinking in online asynchronous discussion groups.

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Turkish Prospective Teachers' Perceptions Regarding the Use of Computer Games with Educational Features

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ABSTRACT

Teachers' perceptions are critical to the success or failure of integrating computer games with educational features into classrooms. Consequently, it is essential to gather information about concerns they might have in regard to using these games in the classroom. This study was conducted to investigate the perceptions and future plans of a group of prospective computer teachers in Turkey. One-hundred sixteen students, from four different universities' Computer Education and Instructional Technology (CEIT) departments, participated in this study. The results of the study reveal that the prospective computer teachers who participated have positive perceptions regarding the use of computer games with educational features in education. Moreover, most of the participants plan to use such games in their future professions, according to their responses. However, some of the participants have doubts, especially concerning the issues of classroom management and the educational effectiveness of computer games currently on the market.

Keywords

Computer games, Educational games, Technology integration, Prospective teachers

Introduction

Computer games have emerged as a popular leisure-time activity for many students (Buchman & Funk, 1996; Cesarone 1998; Durkin & Barber, 2002; Media Analysis Laboratory, 1998; Subrahmanyam, Greenfield, Kraut, & Gross, 2001; Yelland & Lloyd, 2001). Computer games are therefore now attracting the attention of many researchers, who wish to use them as educational tools in the classrooms of this new generation of students (Prensky, 2001). However, even within the USA, direct instructional uses of computers are still uncommon (Molenda & Bichelmeyer, 2005). Grabe and Grabe (1998) even reported a recent situation in which computers were not used effectively in teaching practice, due in part to teachers' attitudes and fears regarding this relatively new technology. Thus, without a knowledge of teachers' and prospective teachers' perceptions and future plans for using computer games in education, any potential innovations in this area may lack utility.

It has been reported that computers' real educational uses are mostly associated with applications such as educational simulations/games and problem-solving (Molenda & Sullivan, 2003). However, these are currently the least used applications, compared to word-processing, e-mail, assessment, and record-keeping (Misanchuk, Pyke & Tuzun, 1999; Molenda & Bichelmeyer, 2005).

Only a limited number of scholarly articles mention educators' views about the use of computer games in education. It would therefore be unwise to suggest integrating computer games into classrooms before more fully investigating teachers' perceptions. This study attempts to fill this gap in the literature. Our particular focus on prospective teachers' perceptions is significant, because the high annual attrition rate for teachers will soon alter the teaching population. Newer teachers may become agents of change in schools. In order to estimate the possibility of change regarding the use of computers, it is therefore very important to understand the current perceptions of prospective teachers in relation to this practice.

This study specifically investigates:

- The perceptions of prospective computer teachers regarding the use of computer games with educational features in education (the participating prospective teachers are all students in the Computer Education and Instructional Technology (CEIT) departments of four different universities within Turkey); and

➢ These prospective teachers' future plans for using of computer games with educational features in their courses, or in learning environments which they will design.

Definitions

In this paper, the terms *computer games, educational computer games*, and *computer games with educational features* are simply defined as follows:

a) Computer games: All computer games on the market.
b) Educational computer games: Computer games developed intentionally for educational purposes.
c) Computer games with educational features: As illustrated in Figure1, the scope of computer games with educational features includes educational games, and also other market games not intentionally developed for educational purposes, but which nonetheless have a positive effect on students' learning or development.

The terms *computer games with educational features* and *computer games* are used according to these definitions consistently in the paper. However, the broader term *computer games* is used in the background section, in place of variety of other terms such as educational computer games, electronic games, and video games.

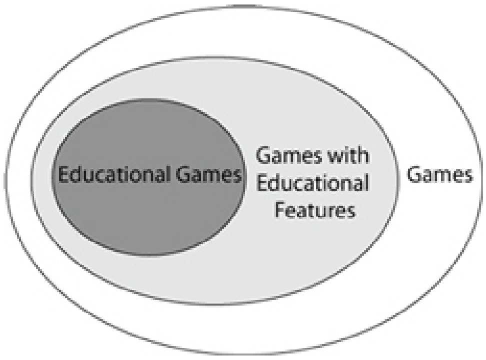

Figure1. Games, educational games, and games with educational features

Background of the Study

Some of the factors that may affect prospective teachers' perceptions regarding computer games and their utilization in courses can be identified as these: the prospective teachers' characteristics and their flexibility in regard to innovation; the current literature available on computer games and their effects on students; societal perceptions that teachers hold in regard to play and gaming; and administrative issues, such as the availability of resources and curriculum considerations.

Teachers' Flexibility in regard to Innovations

Prospective teachers' decisions to use computer games in their courses are somewhat dependent on their flexibility regarding innovation and their awareness of new students' changing interests. Currently, computers are not used as effectively as they could be in schools (Grabe & Grabe, 1998), because teachers either 1) may not know how to use computers to enhance instruction (OTA, 1995; Smaldino, Russell, Heinich, & Molenda, 2005; Whetstone & Carr-Chellman, 2001); 2) may feel anxious about potentially losing their authority (Lunenburg & Ornstein, 1996; Grabe & Grabe, 1998); 3) may not want to change the power and control balance of the current system (Lunenburg & Ornstein, 1996); or 4) may not know how to assess student progress in the new system (Prensky, 2001). In Turkey, teachers generally have positive attitudes toward the use of computers in classrooms. However, their concurrent lack of knowledge and skills for the integration of technology into instruction is a serious barrier which prevents a wide utilization of computers (Cagiltay, Cakiroglu, Cagiltay, & Cakiroglu, 2001).

Current Literature on Computer Games and Their Effects on Students

As presented in Table 1, the respective researchers and theorists have presented contradictory results and assertions concerning the effects of computer games on students. One possible reason for these contradictory studies is that the number of longitudinal studies on this topic is limited. Furthermore, due to a lack of theory and design paradigms for educational games, the quality of the games that were the focus of these studies may have directly affected the results. However, one assertion that most of these researchers do agree upon is that all computer games should not be viewed as valuable, positive, or useful for educational purposes (Prensky, 2001; Rieber, 1996; Subrahmanyam et al., 2001).

Despite several recent research studies on computer games, relatively few studies have been conducted on the implementation of computer games in education. Gredler (1994) described several purposes for using computer games in classrooms. These uses were to practice new knowledge and skills, to diagnose weaknesses in knowledge and skills, to provide review, and to build new relationships with concepts and principles. In addition, Gredler (1994) also proposed that games could be used as rewards. Furthermore, Smaldino et al. (2005) listed some additional applications for computer games. These are to help students to fulfill "cognitive objectives," to motivate them to study dull subjects, to help them to learn without teachers, to improve vocabulary, and to develop "basic skills such as sequence, sense of direction, visual perception, number concepts and following rules" (p. 328).

Table 1. Research Studies on the Effects of Computer Games on Student

Factors	Positive Effects	Negative Effects
Self-esteem	Durkin & Barber, 2002; Malone, 1980.	Negative correlation with frequency of time play for boys, Colwell & Payne, 2000.
Academic achievement	Higher for players who play a little. Durkin & Barber, 2002; Cole, 1996 as cited in Subrahmanyam et al., 2001.	Negative correlation with time spent game playing. Anderson & Dill, 2000.
Social behavior	No negative effect. Colwell &Payne, 2000. Positive effect when played together. Durkin & Barber, 2002; Media Analysis Laboratory, 1998; Prensky, 2001; Rosas et al., 2003; Strasburger& Donnerstein, 1999.	Anderson & Bushman, 2001, 2002; Anderson, 2002; Chory-Assad, 2000. No effect: Phillips, et al. 1995.
Increased aggression	No association with game playing Interactive Digital Software Association, 2001; Durkin & Barber, 2002.	Anderson & Bushman, 2001, 2002; Anderson, 2002; Bartholow & Anderson, 2002; Chory-Assad, 2000.
Addiction	Media Analysis Laboratory, 1998.	Rosas et al., 2003.
Confusion of reality-fantasy	Subrahmanyam et al., 2001; Prensky, 2001 (especially for young children)	
Gender stereotyping		Dietz, 1998; Provenzo, 1992.
Cognitive skills	(In the long term) Cole, 1996 as cited in Subrahmanyam et al., 2001.	Some games require only simple skills. Gredler, 1996. Market games generally include repetitive activities and have negative effects on learning strategies. Coyne, 2003; Gredler, 1996; Price, 1990. Badly designed games have negative effect on learning. Provenzo, 1992. During speedy games, opportunity for reflection is decreased. Prensky, 2001.
Visual skills	Improved "spatial representation," "iconic skills," and "visual attention" Subrahmanyam et al., 2001, p. 13; Greenfield et al., 1994; Greenfield, 1984 as cited in Prensky, 2001.	
Motor skills	Increased performance as time spent. Kawashima et al, 1991.	
Computer skills	Prensky, 2001; Subrahmanyam et al., 2001.	
Problem solving skills	Rieber, 1996.	
Discovery	Gorriz & Medina, 2000; Greenfield, 1984 as cited in Prensky, 2001; Price, 1990.	
Exploration	Prensky, 2001; Provenzo, 1992.	
Engagement-interactivity	Gredler, 1996; Prensky, 2001; Price, 1990; Provenzo, 1992.	
Motivation-flow	Malone, 1980; Prensky, 2001; Rieber, 1996; Rosas et al., 2003.	

Perceptions Concerning Play

Starting with the basic concept of *play*, Glickman (1984) argued that how people perceive play depends on the educational philosophies of their social milieu; these influence the policies in their educational systems (Glickman 1984 as cited in Rieber, 1996). In the literature, although some positive points have been associated with 'play' (Prensky, 2001; Rieber, 1996), certain negative perceptions have also been presented. Some of the negative perceptions include the following notions: play is not serious or respectable; it is applicable only to young children; it is unrelated to learning; it is the opposite of work (Rieber, 1996); it is unproductive; and it requires too much time and effort (Prensky, 2001). However, some parents share beliefs with their children concerning the positive influences of computer games (Sneed & Runco, 1991), and they prefer that their children spend their time using computers rather than watching TV (Kraut, et al., 1996).

Many educators perceive recreational computer games as "time wasters." Some educators also believe that educational games are not beneficial to students (Virvou, Katsionis & Manos, 2005). However, others believe that educational games are important instructional tools (Price, 1990, p. 51; Molenda & Bichelmeyer, 2005). Becker (2001) asserted that entertaining games are generally perceived as not being useful for education, and that academicians think the game market has few educationally valuable products. Teacher interest in using computer games in courses may also decline as the grade-level increases, due to teachers' perceptions that computer games are most effective for elementary school students (Becker, 2001; Rieber, 1996).

Currently, insufficient information is available concerning the perceptions of Turkish society about computer 'play.' However, a recent research study on the use of information technologies, conducted by the State Institute of Statistics in Turkey, reported that 63 % of the respondents use the Internet in order to play or download games or music (TSIS, 2004).

Games and Organizational Issues

New approaches in the education system have been proposed, but change is slow. There is little agreement even about how people learn, which means that significant changes typically require much debate and argument, as well as time (Prensky, 2001). One organizational problem is the teachers' general resistance to change, which is due to their lack of time to learn and apply new technologies (Lunenburg & Ornstein, 1996; OTA, 1995; Molenda & Bichelmeyer, 2005). Another problem is the unavailability of quality resources, such as computers and games (Grabe & Grabe, 1998; Lunenburg & Ornstein, 1996). Though the studies cited above were not conducted in Turkey, here too, the situation is similar in that, a significant barrier which limits the use of computers in courses is the lack of available resources and inappropriate instructional programs (Cagiltay et al., 2001).

Summary

Research studies published on the topic of teachers' flexibility concerning innovation have shown that computers are not used as effectively as they could be, due to the teachers' lack of skills or confidence to integrate this technology into their courses. Controversial results within the current literature concerning computer games and their effects on students might also lead teachers to question the effectiveness of these games for educational purposes. Broader social perceptions may additionally affect teachers' ideas about game-playing activities. Finally, teachers might question the argued need to integrate computer games when they consider the schools' curriculum, the availability of resources, and other organizational issues.

All of these considerations could potentially affect the perceptions of teachers, as well as their future plans to use computer games in their classrooms. These issues should therefore be considered in order to facilitate the successful integration of this technology into school courses. Currently, despite the existence of research studies in these four areas, a critical gap remains in the literature, specifically concerning prospective teachers' perceptions relating to computer games and their uses in education. As it would not be wise to suggest the integration of computer games with educational features into classrooms without first knowing teachers' current perceptions, this study was designed to specifically investigate prospective teachers' perceptions. This will enable us to look ahead, in order to predict the wants and needs of the teaching population in the near future.

Methods

Design

This project was designed as a survey research study. Its main purpose is to investigate and portray the perceptions of prospective teachers concerning the use of computer games with educational features in education. Both qualitative and quantitative data were collected through two survey instruments, a questionnaire and an interview schedule.

Participants

One-hundred sixteen students, from four different Computer Education and Instructional Technology (CEIT) departments in Turkish universities, participated in this study. The aim of these departments is to offer students experience not only with computer literacy but also with instructional technology. Graduates are expected to be able to integrate a variety of technology into their courses.

A two-phase, non-random sampling method was used to select participants. In the first phase, using a convenience sampling method, four public universities in Ankara were identified by both their prestige and their close proximity to the researchers. Secondly, a purposive sampling method was used to select fourth-year CEIT students at these universities. One-hundred sixteen students were recruited to complete the questionnaire. Among these 116 students, four volunteer students from each university (for a total of 16) were selected again to be interviewed.

As presented in Table 2, 32% of the participants were from Middle East Technical University, 30% from Hacettepe University, 19% from Ankara University, and 19% from Gazi University. While in three universities the data were collected from fourth-year students, in METU the data were collected from third-year students. Sixty-two percent of the participants were male, and 38% were female. Students' ages ranged from 20 to 25, with the mean age at 22.1 (SD: 0.91).

Table 2. Participants' Characteristic

		GENDER					
UNIVERSITIES	YEAR	F#	F%	M#	M%	TOTAL#	TOTAL%
Middle East Technical University	3rd year	7	6.03	28	24.14	35	30.17
	4th year	1	0.86	1	0.86	2	1.72
	Sub-Total	8	6.90	29	25	37	31.90
Hacettepe University	4th year	15	12.93	20	17.24	35	30.17
Ankara University	4th year	10	8.62	12	10.34	22	18.97
Gazi University	4th year	11	9.48	11	9.48	22	18.97
TOTAL		44	37.93	72	62.07	116	100

Instruments

Two survey instruments were used to collect data: a questionnaire and an interview schedule. They were both reviewed and revised by experts for their content validity.

The questionnaire is composed of two parts, with a total of 58 total questions. First part can be further divided into two sections, which deal with demographic and computer game-playing characteristics of the participants and their general perceptions toward playing computer games. The second part investigates the participants' perceptions regarding the use of computer games with educational features in education. Aside from some multiple choice, short answer, and open-ended questions, most of the questions are in the form of a four-point Likert scale (Strongly Disagree, Disagree, Agree, and Strongly Agree). A four-point scale was preferred over a five-point scale because of the high number of Neutral responses in the pilot study.

This questionnaire was developed by Gulfidan Can, the first author of this article, but some of the questions were inspired by an existing questionnaire developed for MIT's Games-to-Teach project (Squire & the Games-to-Teach Research Team, 2003). Since the content of this study is new to experts and also new to the participants, pilot studies were conducted to support the content validity of the questionnaire. Sixty-seven different participants in METU participated in that pilot study.

The internal consistency estimates of the reliability analysis for the questionnaire were calculated separately for the different parts of the questionnaire, because the questionnaire is not uni-dimensional and there are different types of questions in it. While the coefficient alpha value for the overall questionnaire is 0.87, for three sections they are 0.79, 0.64, and 0.85, respectively.

In addition to the survey, semi-structured interviews were also conducted with the 16 participants (see Participants, above). Pilot interviews were initially conducted with 17 other individuals from different backgrounds to ensure that the questions were meaningful, understandable, unambiguous, and not leading.

Data Collection Procedure

The data were collected from 116 students in a three-day period, during the students' regular course hours, at the beginning of a class. The questionnaire was used with the permission of the course instructors. The response rates were 100%. On average, the students completed the questionnaires in 10 minutes.

The purpose of the research and the directions for the questionnaires were conveyed verbally by the researcher before the participants were given the questionnaires. The directions for the interviews were also conveyed verbally before starting the interview sessions. Throughout the administration of the questionnaire, one researcher was present in the classroom to answer any problems or questions.

Four students from each university were selected to be interviewed after they completed the questionnaire. Semi-structured interview sessions were recorded with the permission of the interviewees.

Data Analysis Procedure

The data analysis procedure included two main phases: the descriptive statistical data analysis and the qualitative data analysis. Regarding the descriptive data, SPSS software was used for data storage, and for calculation of frequencies and percentages. For the qualitative data, the content analysis method was used, as explained by Yildirim and Simsek (2000). The data were coded, themes were found, and the data were organized and defined according to the codes and themes. Then, interpretations were made. This process was described by Miles and Huberman (1994) as "data reduction," "data display," and "conclusion drawing and verification" (p. 10).

Limitations

The present study has certain limitations that need to be taken into account. Briefly, these are:

- The validity and the reliability of the study are limited by the honesty of the participants' responses to the instruments used in this study.
- Since the participants' perceptions may change in accordance with alterations in their environments and experiences, repeatability may not be possible.
- In one university, the data was collected from third year students rather than fourth year students (since fourth year students were included in the pilot study).
- Even though the same researcher collected the data and tried to standardize the procedure of data collection, there may have been some differences in the experimenter's treatment of the participants during the administration of the questionnaire and during the interviews.
- The participants' conceptions of *computer games with educational features* may be different. It is possible that some of the participants considered only *educational games* when they responded to the questions.

Results

The Participants' General Perceptions regarding Computer Game-Playing

As illustrated in Figure 2, the negative statements selected most often in the questionnaire were that playing computer games requires too much engagement time (85%), it leads to addiction (77%), and it is not an important leisure time activity (63%). Only half of the participants agreed that playing computer games is a waste of time (49%).

The positive statements selected most often were that playing computer games is suitable for every age group (80%), playing computer games is not merely for children (86%), and they help with the development of some useful knowledge and skills (79%). Seventy-two percent of the participants rated this activity as an element that stimulates curiosity in learning. In regard to social behavior, 68% agreed that when computer games are played with a group of people, they help with the development of social skills.

In the interview and short-answer questions, some participants supported the idea that games could be useful for learning skills and knowledge. However, others expressed negative statements, such as: games have more disadvantages than advantages; they are not productive enough; they should only be used for enjoyment rather than for educational purposes; not all market games are useful; and there are no quality games on the market.

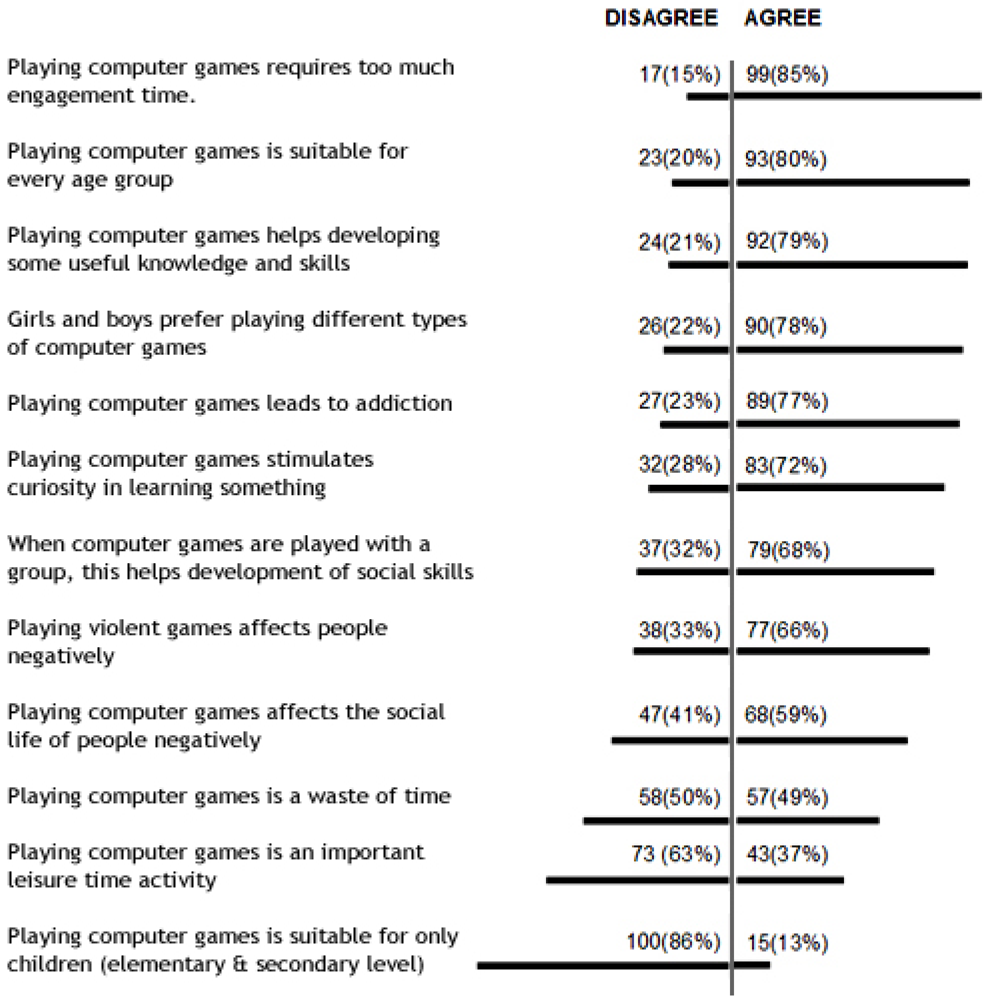

Figure 2. General perceptions concerning computer game-playing

The Participants' Perceptions concerning the Use of Computer Games with Educational Features in Education

While most of the response ratings are positive (see Figure 3), the key disagreements concern the applicability of computer games with educational features for all grade levels (21% disagreed), and that they were suitable for all subject matters (23% disagreed).

The percentages of responses to the questionnaire items revealed that most of the participants supported the idea that computer games with educational features could be suitably used without causing any problems with curriculum plans. About 10%, however, responded that there could be some problems during the use of these games. Ninety-six percent agreed with the statement that computer games have the capability to help students fulfill cognitive goals. Eighty-nine percent of the participants agreed that this kind of computer games could help to develop psychomotor goals. Eighty-seven percent agreed that the games could help students to meet affective goals.

Quotes from the participants' responses to interview and short answer questions are listed below. Among similar expressions, the most representative and comprehensive statements are presented. The more unique statements have been added to the list directly.

Some of the positive perceptions that emerged from our analysis of the interviews and responses to the short-answer questions are as follows:

- Students can learn more useful things using games with educational features than through traditional methods. Moreover, this learning will be more permanent.

- ➢ Students are engaged in activities during the game play; they apply their knowledge; they investigate and discover; and they learn by doing.
- ➢ The students' critical thinking processes will be enhanced, as a result of their dealing with the logical processes of the games.
- ➢ This activity will help them develop their creativity, imagination, and visualization skills.
- ➢ The course content will be more understandable when using games, and previous knowledge will be reinforced by means of the games.
- ➢ Games will also help with the development of eye-hand coordination, interest in computers, and computer-related skills and knowledge.

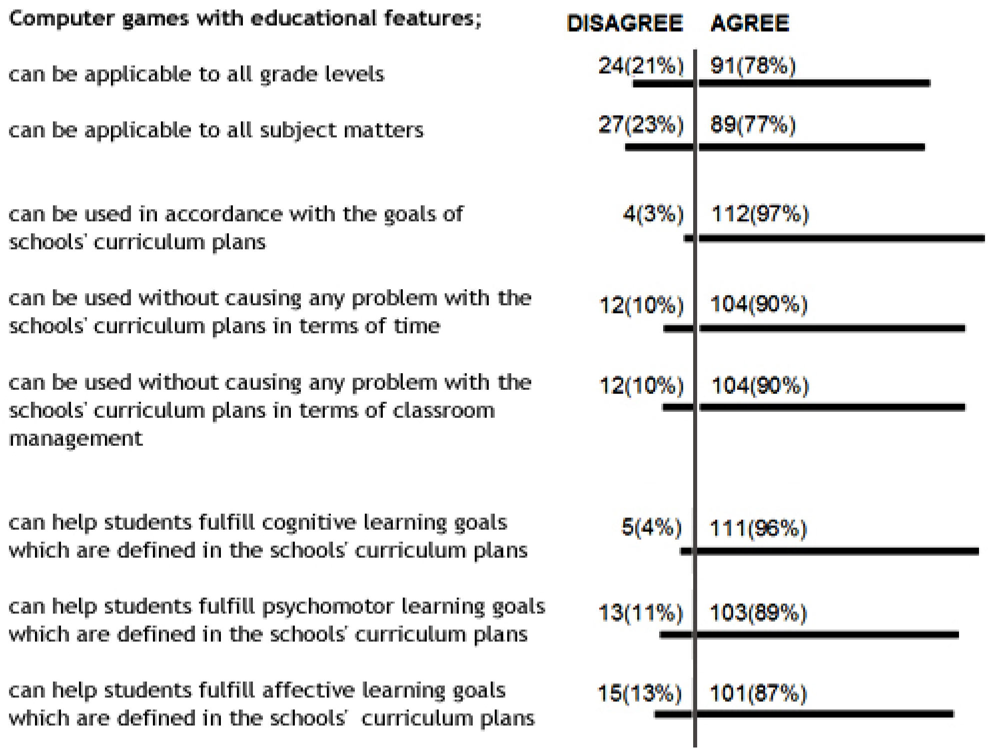

Figure 3. Perceptions regarding the use of computer games with educational features

The negative perceptions were as follows:

- ➢ Students may not understand or learn anything from the games, and these games may prevent students from learning course content if they are played too much.
- ➢ Rather than using games, more productive course activities could be planned, which will be more useful for the students.
- ➢ Some games may restrict creativity.

Classroom Management

Two general patterns were identified in relation to classroom management and the use of games. The comments below explain how using games in the classroom could benefit classroom management.

- ➢ School administration will allow the use of games in the courses, if the outcomes correlate with the intended curriculum standards.
- ➢ Time spent with these games will not be a serious problem, since curriculum plans are not so dense.
- ➢ In the courses, students' motivation, attention, and enthusiasm about learning the course content will increase when playing computer games with educational features. Moreover, the feeling of accomplishment during the game-play will contribute to this motivation.
- ➢ Students will have positive feelings about the teacher, and the teacher will be pleased, since the instructional process will be easier.
- ➢ Teachers do not need to talk much and do not have to give traditional instruction. The students will be silent during the course, and the classroom management will be easier.

➢ Teachers can give more feedback to the students when games are used in the courses. Social interaction among students will increase.

On the other hand, the teachers' perceptions also included some negative visions in terms of classroom management:

➢ Lack of possibilities and administrative issues may limit the use of these games.
➢ Time spent with computer games will be a problem, because they will restrict teaching other course content.
➢ Students may not like the selected game and become bored. They may prefer traditional instruction, surfing on the Internet, or doing something else rather than game-playing.
➢ Students may develop negative feelings toward the teacher because of some of the reasons explained in this section.
➢ It will be hard for teachers to integrate the game and lead the course according to the goals when the games are used and when the goals of the games are not related to the goals of the course.
➢ Students may not be aware of the aim/goals of this activity when they play the game and might begin to wonder how they will be assessed.
➢ In every course, students may want to play games rather than listen to the presentation. It may be hard for teachers to redirect students from games to normal instruction.
➢ Noise may increase during game play, and observing and managing the students will be harder; thus, teachers will be more tired.
➢ Using games in the courses may have a negative effect on students' perceptions toward the importance of the course, which will lower the students' respect for the course.

Other presented doubts are about process effectiveness, suitability of the games for the students' levels, comprehensiveness of the game to cover the content or outcomes, and whether or not students can benefit from these activities.

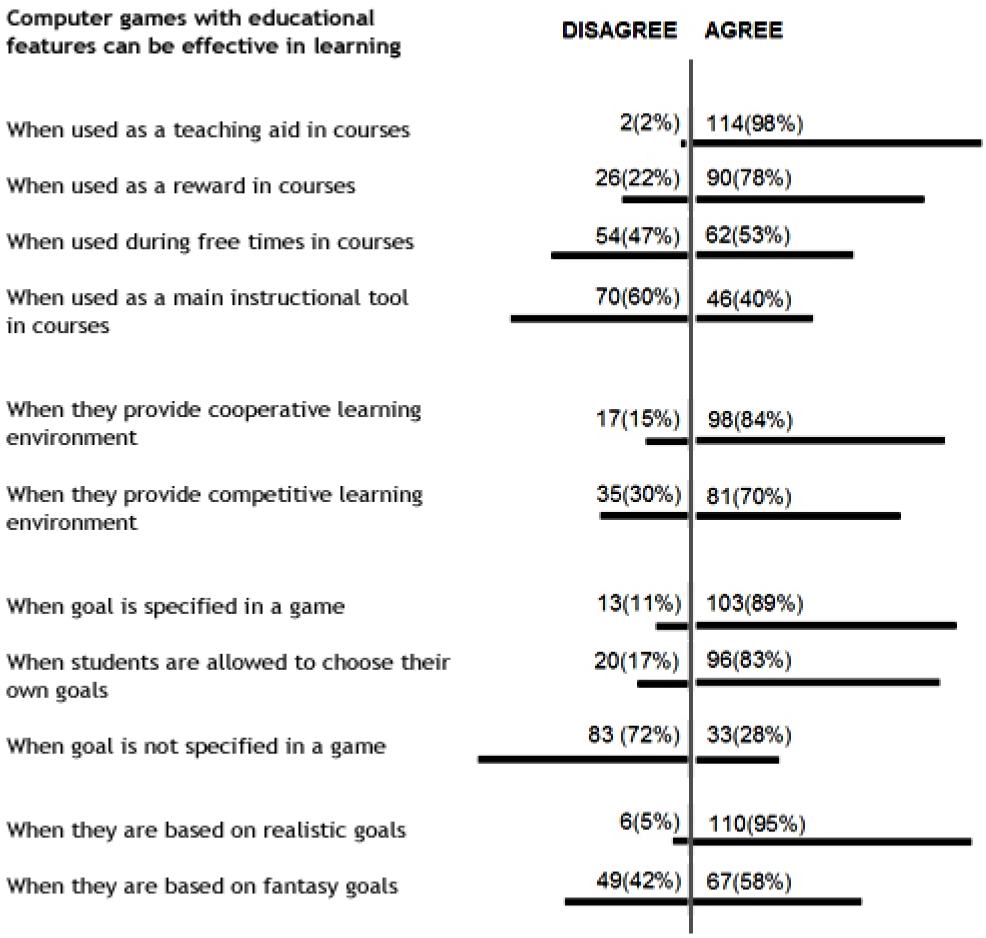

Figure 4. Perceptions about how computer games with educational features should be used

Perceptions about how Computer Games can be used in Education to Enhance Student Learning

The results of the questionnaire show that the participants favored the use of computer games with educational features as a teaching aid in courses (98%) and as a reward (78%) rather than as a main instructional tool (60% disagreed) (See Figure 4). They responded that games with educational features can be effective for learning when they provide cooperative (85%) learning environments. Similarly, 70% of the participants agreed with the effectiveness of using games when they provide competitive learning environments.

The responses to the questions on goal specification and goal nature reveal that the participants support the idea that these games can be effective for learning when goals are specified in a game (89%), when students are allowed to choose their own goals (83%), and when these goals are realistic goals (95%).

The interview and short-answer question responses reveal additional ways of using games with educational features in education to make them more effective for student learning. According to these results, the computer games with educational features can be effective for learning:

- -Time: When used at the end of the lesson, seldom, or as homework.
- -Grade-level and Subject matter: When used to support other courses (not computer literacy courses); and when used in computer literacy courses, and in low grades (elementary school).
- -Game Characteristics: When the games selected are short-duration games or games with various levels, simulation games, games in educational software, and games that require mental activities.
- -Accordance with Goals and Content: When these games are used in accordance with the goals and the content of the lesson.
- Teacher Responsibilities: When extra effort is invested to help and guide students to benefit more from the game, when the course is well-planned (considering the game activities), when the teacher is skillful in applying games in the lessons, and when the teacher informs the students about the purposes of playing games.

Future Plans of the Participants

A majority of the participants (96 participants, 83%) held the opinion that they are planning to use computer games with educational features in their courses in the future. Only 13 participants (11%) expressed that they will not use such games in their courses.

Discussion and Conclusion

One-hundred sixteen prospective computer teachers studying in Computer Education and Instructional Technology Departments in four universities in Turkey took part in this research study. They were highly experienced with computers, and took many courses related to computer literacy and instructional technology. Several of the courses that they took were also related to the integration of technology into courses. Therefore, it is logical to posit that these participants should have more positive attitudes and perceptions regarding the use of new technologies than older teachers or subject matter teachers. The participating, prospective teachers' doubts and fears about computer game use for education may therefore be expected to be found at far higher percentages among other teaching population. For this reason, these doubts must be focused upon more carefully than the positive statements. Commonly occurring themes that were found in this study are presented below:

The Effectiveness of Games, Game Quality, and their Suitability to Goals-Content-Student Level

It is contradictory that half of the participants responded that game-playing is a waste of time, while nearly 80% agreed that computer games have potential for helping students to develop useful skills and knowledge. This situation can be explained by considering the quality level of the computer games that participants referred to when they were answering these two questions.

According to Molenda and Bichelmeyer (2005), the overall sales of educational PC software have actually been dropping in recent years, mainly because of the lack of instructional quality. Regarding this issue, Kirriemuir and McFarlane (2004) reported that irrelevant content or functionality in games can cause obstacles in the use of mainstream games in education. As some of the participants contended, there are virtually no good quality games with educational features on the Turkish market. Correspondingly, the selection of suitable and comprehensive games that meet the goals of curriculum plans, match the contents of courses, and match the students' levels was emphasized as an issue of critical importance in the interview question responses and the short-answer questions.

An enticement toward active involvement in the games, and their effects on motivation and engagement are some of the appreciated features of computer games with educational features. The potential of educational games is well established. However, if the games are not suitable and lack quality in terms of educational benefits, some participants stated that it is better to plan other activities rather than using computer games.

Classroom Management

Although the participants expressed several concerns about classroom management, one common concern was related to the time spent using games in the classrooms. Most participants agreed that computer games with educational features can be used without causing any problems in a schools' curriculum plan in terms of time. However, some of the interviewees who agreed with this statement in the questionnaire expressed doubts about timing during the interviews. Therefore, it is reasonable to assume that the proportion of participants who had concerns about time spent with games was much higher than the reported percentage.

Also, regarding classroom management issues in general, the participants expressed a variety of doubts and fears about using these games in their classrooms. These concerns may lead them to be less confident about integrating games into their courses, especially at the beginning of their teaching careers. Compared to these participants, who have strong technical background, other teachers may not feel very comfortable with technology. Both in Turkey and in the USA, the greatest, current professional development need identified by teachers relates to the integration of technology into instruction (Molenda & Bichelmeyer, 2005). Teachers definitely need strong technical and instructional support to integrate computer games into their courses.

The Teachers' Responsibilities

One perceived drawback of using these games in education is the potentially increased responsibilities of teachers, who must select suitable games and manage the new classroom environment. Some participants thought that they would need to spend more effort and energy on a class when they use games, compared to regular instruction. Considering that some of these participants have neutral perceptions about the benefits of these games, they might think that using the games is not worth the effort required.

Some participants explained that using these games in the classroom requires skillful teachers. In the literature, some scholars have argued that a lack of knowledge about teaching methods for using games in the classroom is one of the most frequently encountered obstacles (Kirriemuir & McFarlane, 2004). Thus, it is reasonable to expect this problem among the prospective teachers.

Implications for Research and Practice

To fill a gap in the literature concerning the perceptions of prospective teachers' about the use of computer games with educational features, this survey research study documents descriptive information that will hopefully incite further research studies in this area. The present study is designed to serve as a representative example, which may also be compared with similar studies.

Though the ratio of students to computers has been improving in Turkey every year, instructional uses of computers are still very limited. The academic literature shows that computer use in schools is mainly centered on administrative tasks and computer literacy applications. However, computers can be powerful instructional tools. Realizing this in effective practice is a challenging task.

Computer games with educational features have great potential to overcome this challenge. Therefore, subsequent studies focusing on the investigation of specific games and game structures relative to educational objectives will help researchers to deeply understand what factors affect their use by current teachers, and their planned use by prospective teachers.

Most of the current teachers in Turkey began their teaching careers prior to the computer era. Newer teachers are therefore more likely to have a higher comfort level with this technology. *Prospective teachers* have the potential power to change future classroom environments, starting with their own. However, they may already possess set ideas regarding games and traditional teaching methods. If they are not shown alternative contemporary approaches, they will most likely teach as they were taught. An introduction of educational computer games in their teaching methods classes should be provided to help these prospective teachers to develop a revised conception of their teaching approaches, and to help them to understand the nature and purpose of computer games in different classes. This introduction should not be limited to merely the tools; it should also require changes in social arrangements constituting teacher preparation (Blanton, Simmons & Warner, 2001). Such arrangements will open new doors in research which promotes different learning interactions, the mediation of social arrangements, and critical analysis and reflection.

An extensive research study should be conducted to reveal the best methods to successfully use these games within the current education system. Questions for this projected study should include the suitability of the games for particular schools' curriculum plans, and how to identify and implement games which are less likely to cause classroom management problems. The results would help prospective teachers who are enthusiastic about integrating computer games into their courses, but have doubts and a lack of confidence, as is indicated in this research study.

Moreover, a longitudinal study would be useful to examine changes in the perceptions of prospective teachers regarding the use of computer games after they have begun their careers and have become involved in real school-life issues. This sort of prospective study would offer important information about how their perceptions could change in the face of encountered difficulties, and what these difficulties might be. Furthermore, the teachers' changing confidence and competence in using these games, as well as their methods for using them, could also be examined.

The curriculum planners should carefully consider the prospective teachers' opinions reported in this research study (and in future, replicable studies) before engaging in any decision-making processes concerning the integration of games with educational features into school courses.

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Automatic Speech Recognition: Reliability and Pedagogical Implications for Teaching Pronunciation

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ABSTRACT

This study examines the reliability of automatic speech recognition (ASR) software used to teach English pronunciation, focusing on one particular piece of software, *FluSpeak, as a typical example*. Thirty-six Korean English as a Foreign Language (EFL) college students participated in an experiment in which they listened to 15 sentences that appeared in *FluSpeak* and recorded their voices, repeating sentence by sentence. The ASR software analysis of their production was then compared to pronunciation scores determined by native English speaking (NES) instructors. Although the correlation coefficient for intonation was nearly zero, indicating that ASR technology is still not as accurate as human analysis, the software may be very useful for student practice with aspects of pronunciation. The paper suggests a lesson plan for teaching English pronunciation through ASR software.

Keywords

Automatic speech recognition (ASR), English pronunciation, Intonation, Pedagogical implications, Software, Pronunciation training

Introduction

Computer-based pronunciation training has emerged thanks to developments in automatic speech recognition (ASR) technology (described in technical detail in Witt & Young, 1998; Herron, *et al*., 1999; Menzel, *et al.* 2001; Beatty, 2003). However, even as foreign language teachers become increasingly aware of the advantages of using ASR software, they have become concerned with the reliability of machine-scored pronunciation.. This concern stems from their belief that a high degree of agreement should be obtained between automatic and human scores. Finding a high degree of correlation between the two would increase the use of ASR software for pronunciation training. Coniam (1999, p.49; 1998) has already suggested the development of an assessment tool, such as a reading aloud test via voice recognition technology; that is, students read aloud sentences that are scored by the voice recognition software.

The prime purpose of this pilot study is to determine the correlation coefficient between the pronunciation scores of one automatic speech recognition software, *FluSpeak*, and those of NES instructors, using Korean EFL college students as subjects. To this end, this paper will undertake three tasks. First, it will briefly overview the architecture of ASR in pronunciation software, including *FluSpeak*. Second, it will describe the experimental procedures employed to determine the correlation coefficient between the scorings *of FluSpeak* software and those of NES instructors and analyze the data used to determine correlations among the several variables. Finally, it will suggest the pedagogical implications for effectively teaching pronunciation with ASR software, both in the classroom instruction and for self-training. The paper concludes by discussing future directions in determining more accurately the correlation between ASR and human scores.

Architectures and Features of ASR

ASR is a cutting edge technology that allows a computer or even a hand-held PDA (Myers, 2000) to identify words that are read aloud or spoken into any sound-recording device. The ultimate purpose of ASR technology is to allow 100% accuracy with all words that are intelligibly spoken by any person regardless of vocabulary size, background noise, or speaker variables (CSLU, 2002). However, most ASR engineers admit that the current accuracy level for a large vocabulary unit of speech (e.g., the sentence) remains less than 90%. Dragon's *Naturally Speaking* or IBM's *ViaVoice*, for example, show a baseline recognition accuracy of only 60% to 80%, depending upon accent, background noise, type of utterance, etc. (Ehsani & Knodt, 1998). More expensive systems that are reported to outperform these two are *Subarashii* (Bernstein, *et al*., 1999), *EduSpeak* (Franco, *et al.,* 2001), *Phonepass* (Hinks, 2001), *ISLE Project* (Menzel, *et al*., 2001) and *RAD* (CSLU, 2003). ASR accuracy is expected to improve.

Among several types of speech recognizers used in ASR products, both implemented and proposed, the Hidden Markov Model (HMM) is one of the most dominant algorithms and has proven to be an effective method of dealing with large units of speech (Ehsani & Knodt, 1998). Detailed descriptions of how the HHM model works go beyond the scope of this paper and can be found in any text concerned with language processing; among the best are Jurafsky & Martin (2000) and Hosom, Cole, and Fanty (2003). Put simply, HMM computes the probable match between the input it receives and phonemes contained in a database of hundreds of native speaker recordings (Hinks, 2003, p. 5). That is, a speech recognizer based on HMM computes how close the phonemes of a spoken input are to a corresponding model, based on probability theory. High likelihood represents good pronunciation; low likelihood represents poor pronunciation (Larocca, et al., 1991).

While ASR has been commonly used for such purposes as business dictation and special needs accessibility, its market presence for language learning has increased dramatically in recent years (Aist, 1999; Eskenazi, 1999; Hinks, 2003). Early ASR-based software programs adopted template-based recognition systems which perform pattern matching using dynamic programming or other time normalization techniques (Dalby & Kewley-Port, 1999). These programs include *Talk to Me* (Auralog, 1995), the *Tell Me More Series* (Auralog, 2000), *Triple-Play Plus* (Mackey & Choi, 1998), *New Dynamic English* (DynEd, 1997), *English Discoveries* (Edusoft, 1998), and *See it, Hear It, SAY IT!* (CPI, 1997). Most of these programs do not provide any feedback on pronunciation accuracy beyond simply indicating which written dialogue choice the user has made, based on the closest pattern match. Learners are not told the accuracy of their pronunciation. In particular, Neri, *et al*. (2002) criticizes the graphical wave forms presented in products such as *Talk to Me* and *Tell Me More* because they look flashy to buyers, but do not give meaningful feedback to users. The 2000 version of *Talk to Me* has incorporated more of the features that Hinks (2003), for example, believes are useful to learners:

- A visual signal allows learners to compare their intonation to that of the model speaker.
- The learners' pronunciation accuracy is scored on a scale of seven (the higher the better).
- Words whose pronunciation fails to be recognized are highlighted.

More recent ASR programs that have adopted HMM include *Subarashii* (Entropic HTK recognizer used), *VILTS* (SRI recognizer), *FLUENCY* (Carnegie Mellon University SPHINX recognizer), *Naturally Speaking* (Dragon Systems), and *FluSpeak* (IBM ViaVoice recognizer). Those interested in more detailed technological descriptions of each ASR program may refer to Holland (1999) and other articles in the *Calico Journal*, Special Issue, Vol. 16 (1999). *FluSpeak* (MT Comm, 2002a), which was used in this study, will be described in more detail in an attempt to show how HMM based programs are built and how they score learners' pronunciation.

FluSpeak is divided into four types of practice: English Pronunciation Practice with consonants, consonant clusters, vowels, and diphthongs; Intonation Practice; Dialogue Expressions Practice; and a Pronunciation Test that covers the Pronunciation and Dialogue activities. Students can listen to sounds or words with an animated video clip showing a native speaker's mouth and tongue movements. They can then record their voice repeating the sounds or words. When their pronunciation is recognized by the software, their pronunciation accuracy is displayed in a spectrogram on the screen, so that they can compare their pronunciation to native speech visually (see Figure 1).

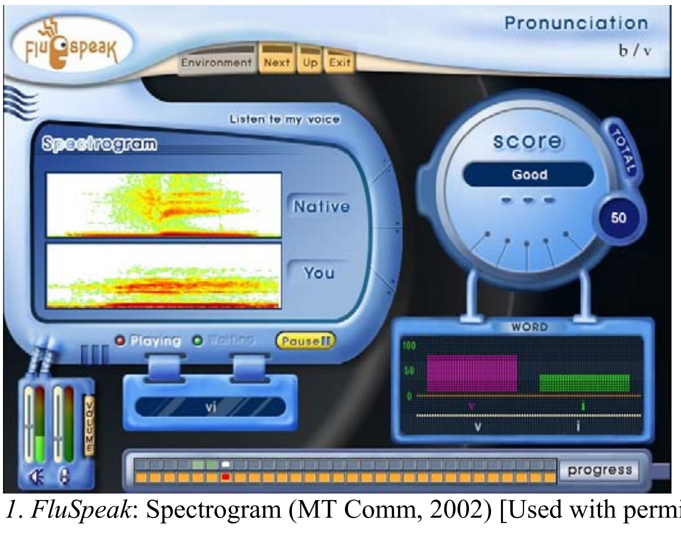

Figure 1. *FluSpeak*: Spectrogram (MT Comm, 2002) [Used with permission]

Besides the video of the native speaker’s face and the spectrogram, visual aids include a graphical display of the vocal tract and speech wave forms.

For Intonation Practice, students listen to the native speaker's pronunciation of a sentence, while seeing the intonation curve shown in yellow on the screen. They then repeat after the native speaker, and the intonation curve of their own pronunciation is visually displayed in red with a score, so that learners can compare their own intonation with the model (see Figure 2, box in upper right).

Dialogue Expressions Practice consists of 40 units of beginning through intermediate dialogues that would be used in ordinary conversations. Students listen to the speaker's model pronunciation as often as they want before recording into the program. When the accuracy of their pronunciation reaches a minimum level of recognition, scores for all individual words in the utterance and their averaged score are displayed on the screen. Until the threshold level of recognition is reached, a voice signal “please try again” is heard. Learners can role-play with the computer by clicking on a button. During practice at this stage, sentences are not displayed in writing to prevent learners from relying on reading the sentences, while repeating them. Learners can also check their performance during practice when each unit is completed. Cartoons depicting the context of the dialogue are displayed in the clock-shaped control panel at the left of the screen (see Figure 2).

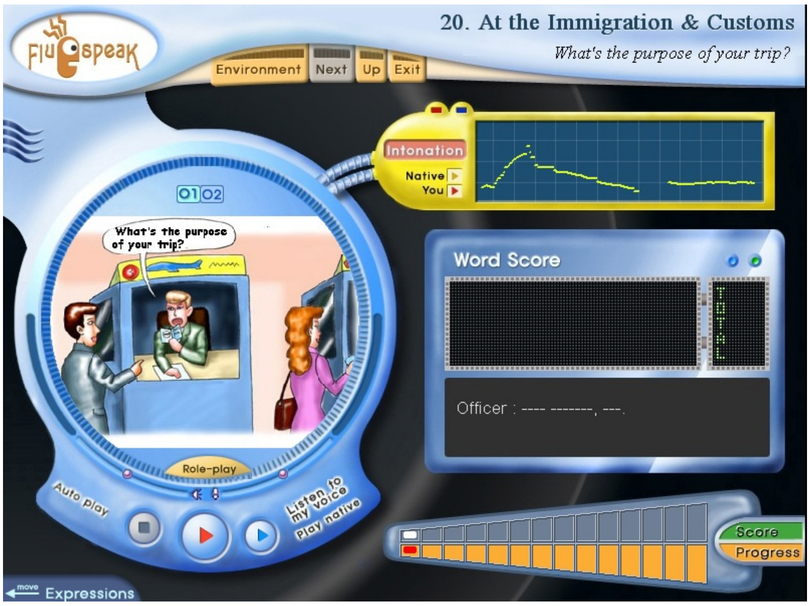

Figure 2. *FluSpeak*: pronunciation Practice.. FluSpeak (MT Comm, 2002) [Used with permission]

FluSpeak's automatic pronunciation scoring system -was developed using 30,000 full phonemic models, based on the utterances of 1,500 native speakers of American English and 200 English learners, and on acoustic information about 200,000 words and their pronunciation variants.

The ARS operates according to a proprietarial recognition algorithm that MT Comm (2002a)developed over many years. According to a research report released by MT Comm (2002b) these phonemic models realistically represent the system of American pronunciation since they are abstracted from the utterances of a large number of native speakers and have proven to be 99.9% reliable in measuring the pronunciation of native English speakers who did not participate in building the original database.

FluSpeak measures the percentage of similarity of the L2 speaker's intonation pattern to the native speaker's intonation pattern. The software searches for the most probable phoneme to best match an utterance, based on the database of 30,000 phonemic models and 200,000 lexical entries. *FluSpeak* computes the score, based on the percentage of a learner's pronunciation accuracy compared to the model, plus a reliability point. However, since intonation refers to low or high pitches in a sentence, it is extremely difficult to register intonation using only a sound wave. In order to do so, abstracting the pitch of the sound signal is necessary. The value of pitch in a high tone is small (narrow), whereas that in a low tone is large (wide). One can compute the vibration value inversely. An additional problem arises in that the value of pitches varies depending on the individual speaker. Thus, it is difficult to determine the degree of correct intonation for different people based on the absolute value of pitch in a sample. To solve this problem, *FluSpeak* does not determine the absolute value of pitch change, but rather it computes the relative change of pitch determined by the length of a sound.

Methodology

Subjects

Thirty-six students enrolled in the author's intermediate General English Division conversation course for the fall semester of 2003 participated in this experiment. Students were admitted to the course as a sequel to a beginning English conversation course which they took in the spring semester of 2003. These students were enrolled in this General English Division course, required for all freshmen, solely based on completion of prior coursework.

Procedures for Collecting Data

Warm-up session

The experimental session used for the study was preceded by a warm-up session during which students were asked to familiarize themselves with the *FluSpeak* software and try it out on their own for twenty minutes at the multimedia lab of the author's university. They practiced repeating the sentences, recording them into the program, listening to their own voice, and comparing their voice with that of native speakers by seeing the scores and intonation curves displayed on the screen. The purpose of the warm-up session was to eliminate beforehand any technical difficulties that might arise from using the software.

Experimental session

Once students were familiar with how to use the *FluSpeak* software, they were asked to glance through a list of 15 sentences on a sheet. They were told that they should read these sentences, one by one, as naturally as possible once after they heard the native speaker's voice on the program. For having their speech recorded they were told to do the following: 1) They click a yellow square button that appears in a row at the bottom of Figure 3. The first yellow square button plays the first sentence. And they then click the play button on the screen of the program. 2) They look over the sentence on the list given, while listening to it on the program. They repeat the sentence they hear as many times as they want. 3) Once they feel comfortable with repeating the first sentence, they click the second yellow square button and listen to the second sentence by clicking the play button. At this stage students' repeating of the first sentence is automatically recorded.

During the warm-up session the author explained to students that they should read the sentences as connected utterances and as closely as possible to the way that *FluSpeak* reads them. Raters were also made aware of the fact that students were supposed to read sentences as connected speech .

A special arrangement was made with the *FluSpeak* producers for students' recordings to be saved into a local file since in the commercial product students' utterances cannot be saved. The experiment used all new sentences unfamiliar to the students but similar to those they had studied during previous coursework. The scores for individual words, bar graphs, and intonation curves were displayed to students as in Figure 3, but only the numeric scores were saved for the purposes of the experiment. Thus, students were able to learn as the experiment proceeded, just as they would have in a normal session with the software. During the experiment students were allowed to practice reading the sentences several times and to save the attempt which they thought was the best. There was no specific time limit set, but the total average time taken for reading the15 sentences turned out to be 30 minutes.

Retrieval of students' speech samples and FluSpeak scores

Thirty-three student utterances (the total completing the study) stored in the experimental file were retrieved and saved onto an audio CD. The remaining three student samples were discarded since these subjects did not complete the entire experiment. As explained earlier, the *FluSpeak* program rates English learners' speech by the accuracy of words within a sentence and their intonation, each on a 100 point scale. These two scores for all speech samples were retrieved and averaged into a mean score to see how the *FluSpeak* scores would correlate with native speakers' holistic ratings. Intonation scores were also retrieved separately in order to determine the correlation coefficient between human scores and those judged by *FluSpeak*.

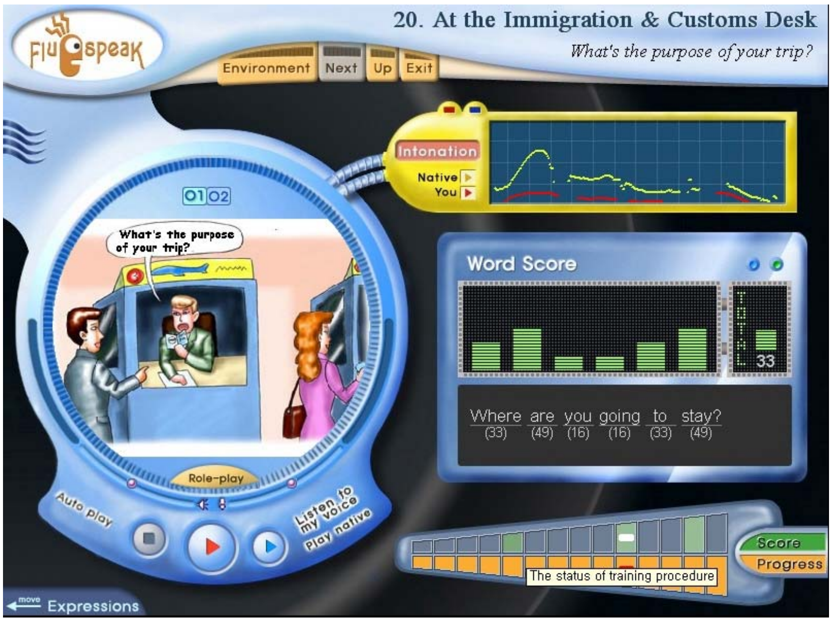

Figure 3. The scores for individual words, bar graphs, and intonation curves displayed to students

Development of the rating scale and scoring of students' speech samples by NES instructors

A review of L2 phonology studies reveals that the holistic rating of fluency is the preferred method because of the difficulty of quantifying prosodic deviance in terms of discrete phonetic errors. Witt and Young (1998) define pronunciation quality as based on both phonetic and prosodic features. They believe that for beginners, phonetic characteristics are of greater importance because these cause mispronunciations. But they stressed that as learners' fluency increases, more emphasis should be given to teaching prosody, i.e., intonation, stress and rhythm (p. 26). The author had to develop a new pronunciation rating scale for this experiment since those existing in the literature did not fit the purpose of this study.

Holistic rating of English learners' pronunciation is reported in a number of studies (Adams, 1979, Prator & Robinet, 1985; Wong, 1987; Anderson-Hsieh & Koehler, 1988; Morley, 1991; Anderson-Hsieh, *at al*., 1992; Koren, 1995; Munro & Derwing, 1995; Derwing & Munro, 1997). Most researchers attempt to measure the raters' overall impression of stress, rhythm, phrasing, and intonation. This study adopted a four-point scale without midpoints between the whole numbers, as shown in Appendix B.

The evaluation method (see Appendix B) that the author adopted in this paper consists of a four point scale, ranging from 0 to 3 without midpoints allowed in-between. Points 0 indicates least-native like fluency in that the speaker's pronunciation entails many pronunciation errors and foreign accents and intonation patterns, which makes the listener get lost. In contrast, Point 3 indicates most native-like fluency in that the speaker's pronunciation entails occasional pronunciation errors, but makes her clearly understood. Point 1 indicates the existence of frequent pronunciation errors and foreign accents and intonation patterns that make the speaker's pronunciation somewhat difficult to understand. But Point 2 indicates the existence of some consistent pronunciation errors and foreign accents and intonation patterns, and yet does not make the speaker's pronunciation understandable with some efforts to listen.

Student speech samples were rated by three NES instructors who were teaching at the author's university. These American instructors (two males and one female) possessed higher degrees in TESOL or Linguistics from American universities. They have been teaching English at the General English Division of the university for some five years on the average, so they are familiar with their students' pronunciation. They were given instruction as to how to rate student utterances using a 4-point rubric and did some preliminary rating practice with speech samples before they scored the student productions for this study. Each of the three raters were given an audio CD that contained student speech samples, and were asked to score the speech samples independently, based on the 4-point scale. They were then asked to write points in the column of the scoring sheet. When they rated students pronunciation, they were asked to remain consistent across all items. Especially when they felt hesitant to rate speech samples, they were asked to listen to them several times and come up with a most accurate rating.

The Pearson correlation coefficient was calculated for the set of three scores thus produced for each speech sample. The ratio (r=0.49) turned out to be not very high, indicating that the ratings were not consistent across the three scorers. The instructors were then asked to rate the speech samples again, this time discussing the scores when they were not within one point of each other on the rating scale until they arrived at closer agreement. The Pearson correlation coefficient for these adjusted scores went up to 0.69, which means that the scores determined by this adjustment process were relatively reliable. The final scores of all three raters on the experimental data were subsequently averaged into mean scores.

Integration of scores for cross-comparison

FluSpeak scores for word and intonation and their averaged totals were recorded into the table of raw data for ananlysis.

Data Analysis and Discussion

The *WinSPASS* program (SPSS Korea, 2002) was run on the four kinds of pronunciation ratings appearing in Appendix C to calculate correlation coefficients between *FluSpeak* ratings and those of native instructors. Correlation coefficiency between two variables for each speaker was computed in order to assess their consistency.

Correlation between FluSpeak ratings and those of NES instructors at the speaker level

Mean scores for words and intonation, as rendered by the *FluSpeak* program, are juxtaposed with those of native instructors per speaker (Appendix C, last row). The mean score at the word level judged by *FluSpeak* is 46.3 indicating poor pronunciation (less than 50% accuracy), whereas that of the NES teachers is 1.9, or only a little less than 50%. The correlation coefficient between *FluSpeak* scores and NEI's scores at the speaker level is 0.56 ($p<0.01$), that is, not very high, indicating a mediocre correlation between the two types of scores (see Table 1).

Table 1. The correlation coefficient between *FluSpeak* scores and NEI scores

Variable	**Number**	**Mean**	**SD**	**Correlation Coefficient**
FluSpeak Scores	33	46.3	9.3	**r=0.56 ($p<0.01$)**
NEI Scores	33	1.9	.41	

However, as Table 2 demonstrates, the correlation coefficient between *FluSpeak* scores for intonation and NEI scores for general fluency is extremely weak (0.06, $p>0.05$). This indicates that the accuracy of judging intonation by *FluSpeak* may not be reliable at all.

Table 2. The comparison between *FluSpeak* scores for intonation and NEI scores for general fluency

Variable	Number	**Mean**	**SD**	**Correlation Coefficient**
FluSpeak Scores	33	70.4	13.7	**r=0.06 ($p>0.05$)**
NEI Scores	33	1.9	.41	

One major reason for this weak correlation originates in the varying pitch uttered by different people. Since *FluSpeak* measures the percentage of the similarity of L2 speakers' intonation pattern to that of the native English speakers, whose pitch varies naturally, one may assume that its score is likely to be unreliable. The way in which *FluSpeak* measures pitch contributes to its mean score (70.4) for intonation being much higher than that for the word scores (46.3). Another reason which seems to contribute to the unreliability of the *FluSpeak* scoring system is related to construct validity. *FluSpeak* intonation is calculated on an algorithm which measures the intonation accuracy of students' speech samples. However, native speakers' scores are based on evaluating the overall fluency of students' speech, but not just their intonation. Thus, failure to establish any relationship between these two variables is not surprising since a comparison is being made between two scores that measure different objects. One way in which we can solve this kind of problem is to compare *FluSpeak* intonation scores with those that come from humans judging intonation only (if that is possible), a test which was not done in this study.

One may cautiously conclude that the reliability of the *FluSpeak* scoring system is only moderate at the speaker level (0.56). This conclusion appears to be supported by the performance reports for software in several studies which looked at the reliability of their ASR engines. Franco, *et al.* (1997) and Kim, *et al*, (1997) report on correlations at three different levels between human scores and machine scores created by Stanford Research Institute's ASR engine: 0.44 correlation between these two variables at the phoneme level, 0.58 at the sentence level, and 0.72 at the speaker level using 50 sentences per speaker. Ehsani and Knodt (1998) compare machine-human correlations with correlations between human graders: 0.55 at the phoneme level, 0.65 at the sentence level, and 0.80 at the speaker level. Another set of studies with similar results include Rypa and Price (1999), who report a comparable relationship at the sentence level between human-machine score correlations (*r*=0.60 on data drawn from the *VILTS* system they developed) and human-human correlations (0.68) between human scores and those of ASR software reported in Niemeyer, *et al.* (1998). A recent study done by Machovikov, et al., (2002) reflects more or less the same degree of correlation between experts' rating and the ASR system's for speaking 10 Russian digits (approximately 73%). See Table 3 for a comparison of these correlations.

*Table 3***.** Aspects of correlations between human and machine pronunciation scoring

Variable	Franco (1997); Kim et al. (1997): human-machine	Ehasani & Knodt (1998): human-human	Rypa & Price (1999); Niemeyer et al. (1998): human-machine	Rypa & Price (1999): human-human	Machovikov et al. (2002): human-machine
phoneme level	0.44	0.55			73%
sentence level	0.58	0.65	0.60	0.68	
speaker level	0.72	0.80			

The findings of these studies lend support to a belief in the reliability of the *FluSpeak* scoring system despite the apparently low correlations obtained in this small-scale study. The correlation coefficient of *FluSpeak* at the speaker level (*r*=0.56) runs considerably lower than that of SRI's system (*r*=0.80; Ehasani & Knodt,1998), but is comparable to that of *VILTS* (*r*= 0.60; Rypa & Price, 1999). A somewhat low correlation score by *FluSpeak* at the speaker level leads to the speculation that it may be more vulnerable to the idiosyncratic nature of the speaker's pitch. This is a subject for further investigation.

There are other studies that look at other aspects relevant to the reliability of ARS scoring systems. Bernstein (1997) claims that the correlation level between machines and human graders can be as high as 0.85, based on a study conducted at Entropic with 20 to 30 short sentences per speaker. However, one may argue that such a correlation may not be a realistic goal once the system deals with longer sentences, *e.g.*, those consisting of more than five words. A case in point is *PhonePass* (Ordinate, 2000; Berstein & Christian, 1996) which demonstrates the highest correlation coefficient (0.94) between human and machine scoring so far (288 non-native speaker subjects). However, the majority of utterances tested in *Phonepass* are words or phrases. Even when sentences are used, most of them are relatively short and loaded with somewhat easy words. In contrast, utterances tested in *FluSpeak* are relatively long, consisting of up to 12 words in dialogue form, and-furthermore, are loaded with multi-syllabic vocabulary items such as *landing card*, *purpose*, *declaration*, *belongings*, and *agricultural products*. It may be assumed that the greater number of words per sentence and their level of difficulty explains the difference in correlation ratios between *FluSpeak* and other products. This assumption is supported by the result that *FluSpeak* scores for longer sentences (*i.e.*, sentences 1, 3, 7, 10, and 11 in Appendix A) with multi-syllabic vocabulary turned out to be considerably lower than scores for shorter easier sentences. One might assume that an increase in the number of utterances per speaker would increase the correlation coefficient further. However, a decrease in the number of words per sentence may be a more powerful indicator.

The Setting of the Recognition Accuracy Rate

Another aspect of ASR scoring is the setting of the recognition accuracy rate. Ehsani & Knodt (1998) report that certain software, such as *Subarashii* (a Japanese language learning software), is built with a relatively low recognition accuracy rate in order to forgive students' accents. According to their two trial experiments, using 45 students studying Japanese as a foreign language, recognition accuracy rates turned out to be extremely low (46% for the high school version and 36.6% for the Stanford university version). Naturally, the functional accuracy scores reported by the program in each case turned out to be relatively high (66.9% and 71.4% respectively). Ehsani & Knodt argue, however, that near perfect recognition accuracy may not be a necessary requirement for an effective speech or dialogue teaching system (1998, p. 55). However, the claim that recognition accuracy should be lowered at the expense of correcting faulty pronunciation does not appear to have face validity as a pedagogically sound approach. In fact, many ASR products allow users to adjust the difficulty level of sound recognition, depending upon the level of their expectations. Thus, a teacher could adjust the accuracy level very low so as not to discourage beginners, or raise it very high to work with advanced students.

Pedagogical Implications for Teaching English Pronunciation

Teaching pronunciation to EFL students at a low level can be a labor-intensive task for EFL instructors, especially when their classes have 30 to 40 students with a diverse range of proficiency levels. However, ASR pronunciation software such as *FluSpeak* can be used effectively in conjunction with live classroom teaching to develop oral skills. The author has taken the following four steps to blend live teaching with self-training in pronunciation for students enrolled in an intermediate English conversation course.

Step 1: Choral repetition of each sentence after the speaker in FluSpeak software

This step is a tuning-up session where instructors let students know what they are going to learn. If necessary, instructors explain the meanings of key words and useful expressions that need special attention. Students repeat after the model speaker on the software. During this time they are allowed to look at the sentences in the book.

Step 2: Self-training initiated by students

Once students have established some degree of familiarity with the target sentences in class, they can spend more time with the software in the lab, working sentences that are problematic for them individually. When students see the score of their own pronunciation on the screen, they have good reason to try again to reach a higher score. This motivation makes students stick to self-training and use the software for a longer period of time. One teaching tip is that adequate lab time should be allocated for students' self-training with the software. Their practice recordings are, of course, kept in the program file for the instructor's review.

Step 3: Instructor's Q & A session

An instructor takes up a whole class session to practice the dialogue student by student or in chorus. By this time students should feel somewhat confident with speaking the sentences since they have self-trained with them on the ASR software. The instructor asks the question in the dialogue and students respond individually or in group. During this time various other skills such as reading aloud can be practiced.

Step 4: Student pair practice.

Once students are ready to use the sentences in Steps 1 through 3, pairs of students sit near each other and take turns reading the dialogue sentences to their partners.

Step 5: Students' simultaneous repetition with the model pronunciation on the software

In a subsequent lab session students try to repeat the sentences almost simultaneously with the model speaker. At this step students are encouraged not to look at the script of the sentence they are repeating. This is the point where the fluency they worked on during the previous steps becomes evident.

Step 6: Role-play session and other creative skill-using activities

Students are given an opportunity to role-play the dialogues in front of the class without looking at the script. Other creative skill-using activities include making up new dialogues based on the one they learned and pair or group presentation in front of the class.

The lesson plan above exemplifies the case where ASR pronunciation software leads to communicative skills. In the author's experience students feel more confident with speaking in class when they have practiced pronouncing the sentences privately. Also, were instructors to spend much time drilling students with pronunciation of the basic sentences in the dialogue, which is often the case, they would not have a reasonable amount of time to provide the opportunity for communicative practice. Furthermore, instructors tend to agree that this type of pronunciation drill is not always as successful as it should be and rarely can be adequately individualized. Thus, ASR use has two advantages: (1) students feel more confident in their speaking skill with individualized ASR-based training, and (2) human instructors can plan on more motivating communicative activities if they leave the low-level basic pronunciation drills to the ASR software.

At the end of the class that the author taught during this study, he took a survey to determine students' reactions to this ASR-based pronunciation class. The survey showed that an overwhelming number of students (90%) reacted positively to the question, "Do you think that *FluSpeak* helps you improve your English in general ?" Their response to the question "Do you think that *FluSpeak* helps you improve your pronunciation?" was slightly lower (86%), and yet still highly favorable, indicating that students perceived an educational benefit from using the software. However, only 30 % of students answered favorably to the question, "Do you think that the pronunciation and intonation ratings of *FluSpeak* are accurate?" This indicates that students tend to discredit the *FluSpeak* software as a reliable tool for evaluating their pronunciation. One of the reasons for their apparent discontent with this aspect of the software might have something to do with the low pronunciation scores the software gave them. Several students complained about low pronunciation scores from *FluSpeak*, even though their pronunciation seemed to be above average as far as the author could judge them. Their idiosyncratic pitch may have been the culprit.

Conclusions and Future Directions

This study attempts to determine the correlation coefficient between the scores of ASR software and those of human raters, and to speculate on some of the reasons for apparent discrepancies between human and machine raters. An analysis of the experimental data using 36 Korean EFL university students reveals that the correlation coefficient is not high at the word level and near zero at the intonation level. These results hammer home the fact that the present state of technological development falls far below the desired level of accuracy. This, nevertheless, does not indicate that there is no value in adopting ASR software for pronunciation instruction in and out of the EFL classroom. Despite the fact that ASR software has its own limitations, as evinced in this study, it can be used as a valuable tool for teaching pronunciation to EFL students where NES instructors are not readily available. Related to this, the paper has addressed pedagogical and design implications for teaching English pronunciation to EFL students.

To extend this study and validate the pronunciation scoring system of *FluSpeak*, or of any other ASR software for that matter, two research directions are conceivable. First, an experiment with the word recognition error rate of *FluSpeak* can be conducted to determine the accuracy of its scoring system more precisely. Word recognition error rate is widely used as one of the most important ARS measures (Jurafsky & Martin, 2000), and can be computed by a relatively simple formula, *i.e.*, divide the words substituted for correct words, plus words deleted or inserted incorrectly, by the actual number of correct words in the sentence:

$$\text{Word Error Rate (\%)} = \frac{\text{Substitutions + Deletions + Insertions}}{\text{No. of words in the correct sentence}}$$

(Jurafsky & Martin, 2000, p.420)

In this formula, the lower the percentage, the more accurate the word recognition system. As a rule of thumb when the word error rate exceeds 10%, a new algorithm needs to be developed (Jurafsky & Martin, 2000). It would be interesting to compare the correlation coefficient determined in this type of experiment with the word recognition error rate of the ASR software explored above. Second, an experiment is needed to determine whether ASR software accurately judges native speaker pronunciation. If the recognition rate of *FluSpeak* reaches somewhere around 80% for native speakers, one can say that its scoring system is highly reliable.

In conclusion, ASR pronunciation software is not perfect nor will it be in the immediate future (Nerbonne, 2003). However, it should be born in mind that ASR can be a valuable teaching aid for many foreign language learners. Furthermore, foreign language instructors will come to enjoy how much energy is saved for creative activities in their pronunciation classes. Atwell (1999) tells us that the incorporation of speech recognition technology into CALL software, along with moves to greater learner autonomy and the increase in open learning approaches, may in time offer new ways of constructing the learning experience, while fundamentally changing the balance between classroom and individual learning (p. 29). In the seminal book, *Technology-enhanced Language Learning*, Bush & Terry (1997) envision that from "curricular objectives to lesson planning . . . from teacher training to software applicability, there will be no aspect of foreign language learning that will not be influenced by the technological revolution" (p. xiv). This revolution will make the foreign language instructor's language teaching job more creative, less labor intensive, and even more enjoyable when he or she is willing to embrace the technological changes that have surfaced in the foreign language classroom of the 21st century (Egbert &Hanson-Smith, 1999; Kim, 2003), one case in point being the ASR pronunciation software which this paper has explored.

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APPENDIX A. The List of Sentences Read by Students

Dialogue 1: What's the purpose of your trip?

1. Please give me your landing card and let me see your passport.
2. What's the purpose of your trip?
3. I'm here on business, and I'm going to visit a relative.
4. How long will you be staying?
5. Where are you going to stay?
6. Enjoy your visit.

Dialogue 2: Do you have anything to declare?

7. May I see your passport and declaration card, please?
8. Do you have anything to declare?
9. I don't think so.
10. I have my personal belongings and some presents.
11. Are you carrying agricultural products such as fruits or seeds?
12. Would you mind opening your bag?
13. Is this CD player a gift?
14. No, it's for my own personal use.
15. OK. That'll be all, thank you.

APPENDIX B. Pronunciation Rating Scale

"Overall prosody" measures the raters' holistic impression of stress, rhythm, phrasing, and intonation. A four-point scale, with no midpoints between the whole numbers, is used.

Rating Scale

Least Native-like |----------------|---------------|----------------| Native-like
0 1 2 3

Pronunciation Accuracy Rubric

0 Many pronunciation errors and foreign accents and intonation patterns that cause the speaker's pronunciation of the sentence to be completely unintelligible.
1 Frequent pronunciation errors and foreign [non native-like] accents and intonation patterns that cause the speaker's pronunciation of the sentence to be somewhat unintelligible.
2 Some consistent pronunciation errors and foreign [non native-like] accents and intonation patterns, but the speaker's pronunciation of the sentence is intelligible only with some effort.
3 Occasional nonnative pronunciation errors, but the speaker's pronunciation of the sentence is clearly intelligible with effort from the listener.

Sample Scoring Sheet

Item	2	6	7	8	10	13									
1	1	1	1	2	2	1									

Important points to be aware of when rating students' pronunciation:

Be consistent across all items and all students in rating students' pronunciation.
If you are not sure of a student' pronunciation, listen to the item again.

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On the Emergence of New Computer Technologies

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ABSTRACT

This work presents a review of the development and application of computers. It traces the highlights of emergent computing technologies shaping our world. Recent trends in hardware and software deployment are chronicled as well as their impact on various segments of the society. The expectations for the future are also discussed along with security concerns. It is concluded that a major technological challenge being addressed is making information and computing power accessible anytime, anywhere and on any device. We note that worthwhile solutions will also address efficiency and security concerns.

Keywords:

Computer, Technology, Internet, ICT, New trends

Introduction

The computer has been widely deployed within the last decade to almost every conceivable sector of human endeavor. Improvement to computing processes, applications and tools are developed regularly as well as new products and services. This write up will offer information on evolving trends. A useful metric for the rate of technological change is the average period during which speed or capacity doubles or, more or less equivalently, halves in price. For storage, networks, and computing power, these periods are around 12, 9, and 18 months, respectively (Foster 2002). Such is the growth rate within the information and communication technologies (ICT) industry in recent years.

Definitions

The Webster's Dictionary (2002) defines "*New*" as that which just evolved, first-timer, recently discovered or learned, previously unknown or that which is unfamiliar and does not conform to established tradition. This succinct definition captures the context in which we use the word. Asaolu (2001) extended the MSE (2000) definition by stating that, "a computer is a programmable electro-mechanical device, which accepts data and processes such according to some prescribed instructions by performing calculations on numerical data or by compiling and correlating other forms of data. It supplies the result in a specified format, as useful information or as signals to control other machines or processes." Technology refers to applied science, standardized means and ways of adapting scientific principles for the design, production and maintenance of goods and services to meet human needs. It includes information, techniques and tools with which people utilize the material resources of their environment to satisfy their needs (Olunloyo 1997).

In the twentieth century, scientists and engineers collaborated to devise new ways of capturing, processing, storing, transporting and displaying information. From the Post-office and telegraph to mobile phones on one hand, and from the television, the computer and satellite on the other, Information and Communication Technologies merged to become a distinct field popularly referred to with the acronym ICT. Its development and effect on society have been profound. It has impacted the way we work or play. ICT encompasses all those technologies that enable the handling of information and facilitate different forms of communication among human actors, between human beings and electronic systems and among electronic systems. These ICT according to Hamelink (1997) include:

> *"Capturing technologies* to collect and convert information to digital input. These produced the keyboard, mice, joystick, touch-screens, voice recognition systems, bar code scanners, image scanners and palm-size camcorders.
> *Storage technologies* to store and retrieve information in digital form. These led to magnetic tapes, floppy and hard disks, RAM disks, optical disks such as CD-ROMs/DVD, smart cards, memory sticks, etc.
> *Processing technologies*, creating the systems and applications software required for digital ICT.

Communication technologies producing devices, methods and networks to transmit information in digital form. These include digital broadcasting, cellular networks, LANs and WANs (e.g. intranets and the Internet), modems, fax machines, etc.
Display technologies, which create a variety of output devices for the display of digitized information. Examples are computer monitors, printers and plotters, DVD, TiVO, voice synthesizers and virtual reality goggles / helmets."

Evolution of Technology

From the use of fingers and toes, to stones and bones, man proceeded to invent several apparatus that led to the modern machine for computing. The computer of today (or tomorrow) is light-years ahead of any that would have been conceived by Leonardo da Vinci. The evolution of ICT has spanned several centuries; the advancement within the last half-century is truly enormous. Information signals (sound/voice and data –text or pictures) converged into digital form –the binary language of computers and, could thus be transmitted for shared usage through communication devices and other electronic products. Hence we had convergence of and, development of multifunctional technological products that offered users mobility and shareability of services.

The military, the corporate bodies and the innovative entrepreneur have seen to the ascent of technology over the ages. The technological environment changes so drastically that a human generation witnesses multiple technological generations. Technology has not only brought increased standard of living, it has also brought along competition among nations seeking dominance in the new world order. It is even argued that ICT growth also enabled the dark sides of computing such as privacy intrusions, data destructions and easier means to spread moral perversions and ideologies.

Characteristics of Technology

- present in all cultures
- knowledge based and involves application of knowledge to solve problems
- it is accumulative
- it is fundamental to humanity and survival
- it alters culture and society
- it is observable and future oriented
- it seeks a harmonious relationship between human life and nature
- it is an extension of human body and faculties

Levels of Technology

Low-level technology (before 3200 BC)
- characterized by basic primitive tools and machines be it natural, adapted or manufactured
- tools include bows, arrows, spears, stone hammer, store axe etc
- machines include lever, wedge inclined plane, pulley, wheel and axe etc.

Intermediate-level technology (3500 BC to date)
- characterized by tool manufacture for multiple purposes in different sizes by use of different materials
- intermediate level machines differ from primitive ones by role of prime movers such as wind, water and other natural forces as well as steam engines, the electric motor, steam turbines, internal combustion diesel engine etc.

High-level technology (1950 AD to date)
- characterized by high level tools (usually automated) and machines, emphasis of hi-tech is more on assisting the mind not the body
- high level technology further subdivided into 'Fordist' and ICT depending on the level of emphasis placed on standardization and automation on the one part (Fordist) or information and communication technology on the other (ICT). These features are enumerated in Table 1.

ICT is appreciated when these technologies help users to be efficiently productive or relaxed (entertained), this means the user must feel a sense of security, mastery and accomplishment.

Table 1. Comparison of high level technologies

Fordist (Old)	ICT (New)
Energy-intensive	Information-intensive
Standardized	Customized
Rather stable product mix	Rapid changes in product mix
Dedicated plant and equipment	Flexible production systems
Automation	Systemation
Single firm	Networks
Hierarchical management structures	Flat horizontal management structures
Departmental	Integrated
Product with service	Service with products
Centralization	Distributed intelligence
Specialized skills	Multi-skilling
Minimal training requirements	Continuous training and re-training
Adversarial industrial relations; collective agreements codify provisional armistices	Moves towards long-term consultative and participative industrial relations
Government control and planning and sometimes ownership	Government information, regulation, coordination, and 'Vision'
Capital intensive (funded by the government or through loans, etc.)	Phased investment (by individuals, venture capitalists, etc.)
Emphasis on full-time employment for adult (16-65) male workers	More flexible hours and involvement of part-time workers and post-retirement people

How and when are we to invest in new technologies?

According to Olunloyo (2003), the objective is to maximize returns on investment and seek out technologies that;

- Require short diffusion time and high penetration within economy
- Require modest capital outlay for high returns
- Benefits from convergence of technical infrastructure within the economy
- Allow investment to stimulate technological chain reaction

Technology brings development. To be sure, when technology is disruptive, it beckons at investment; otherwise investment rides on product demand to seek out the appropriate technology. Investment into new base technologies eventually leads to industrial waves which, in turn are presumed to produce economic waves that could be described for example by Kondratieff's Cycles (Godet 2000).

Computers and the Internet

The computer has indeed come a long way. Initial key contributors to this concept and product include John Napier, Blaise Pascal, Gottfried von Leibniz, Joseph Jacquard, Charles Babbage, Herman Hollerith, John V. Atanasoff, Clifford Berry, Konrad Zuse, Howard Aiken, John Mauchly, Presper Eckert, Remington Rand, Alan Turing and John von Neumann to name a few (Parker 2003). The computer (machine and accessories) constitute *hardware* while the programs (coded instructions) used for various purposes and tasks are known as *software*. The following computing eras are widely acknowledged:

- First Generation Computers (1939-1954) - vacuum tube based.
- Second Generation Computers (1954 -1959) – transistor based.
- Third Generation Computers (1959 -1971) – integrated circuit based.
- Fourth Generation Computers (1971-Present) – microprocessor based.
- Fifth Generation Computers (Present and Beyond) – offers portability, embedded intelligence and distributed computing.

The Internet is a vast and complex network of networks that connects computers around the world; it is changing social, political, and economic structures, and in many ways obviating geographic boundaries. Its history is well documented (WebDevelopers 2005). The Internet began as a U.S. Department of Defense (DoD) project to interconnect or network DoD-funded research sites in the U.S. in the mid 1960s through the Advanced Research

Projects Agency (ARPA). The fundamental technology that makes the Internet (initially ARPANET) work is called *packet switching*, a data network in which all components (i.e., hosts and switches) operate independently, eliminating single point-of-failure problems. In addition, network communication resources appear to be dedicated to individual users but, in fact, statistical multiplexing and an upper limit on the size of a transmitted entity result in fast, economical networks. It is based on Transmission Control Protocol (TCP) for end-to-end network communication and Internet Protocol (IP) for routing packets and device-to-device communication. There are companies described as Internet Service Providers, which handle all the technicalities and provide (connection) access for subscribing computer users. Such companies use various modes of electronic data delivery and / or communication: from telephone dial-up to wireless satellite transmission.

Some of the popular offshoots or by-products of the Internet include;

- *The World Wide Web or WWW* – a collection of linked electronic files\documents offering vast information on any subject, residing on numerous accessible servers. Indexing services and Search Engines enhance their usage. The WWW is itself based on the hypertext and file transfer protocols (http and ftp).
- *E-mail or electronic mail*, which has been estimated to have a superiority ratio of 240:1 to its *fax* predecessor. E-mail has almost totally taken over electronic document transmission and relegated the delivery of written or bulk printed packages to the conventional post-office.
- *Electronic-chat and messaging***,** this system allows remote users to participate in real-time textual, graphic and voice conversations. Such free services offered by multinationals such as Yahoo!, AOL, MSN, Google, etc. (who derive the substantial portion of their revenue from advertisers and other subscribers services) has opened up a new vista in modern communications. Newsgroups or electronic bulletin boards have developed as another method of communication on the Internet. There are thousands of different newsgroups, each dedicated to the discussion of a different topic. Each newsgroup has its own designated subject area that people in that group are interested in discussing. Then, within each group "threads" or conversations about an aspect of the topic will emerge. Members in the newsgroups communicate by "posting" (mailing) messages to the newsgroup.
- *Internet-telephony* based on Voice over Internet Protocol (VoIP). This allows making telephone calls over the Internet; it effectively transforms expensive international calls into almost cheap local calls!
- *Interactive Content Delivery Services*; these have been harnessed to develop new paradigms such as e-learning, e-governance, e-commerce, e-dating, e-conferencing, etc. These online services allow people to offer and receive distant education, business transactions, meetings, news and reports, medical and other consultations, etc. They are usually implemented as Web Portals having Frequently Asked Questions (FAQ), Feedback and Discussion Forum sections.

There is a closing gap between introduction of technology and its diffusion or penetration as shown in Table 2. This is a delight to the liberal world and chagrin to repressive governments.

Table 2. Rate of Penetration of New Technology

Product	**Time taken to reach 60 million people**
Radio	30 years
Television	15 years
Internet	3 years

Recent Trends

Ironically, change is reputed to be the only constant in the universe. This explains why the ICT innovations of the past are getting antiquated and, why our present prided ICT inventions will someday become obsolete.

Hardware Progressions

Hardware core components have been progressively improved over the last century to electronic systems utilizing the vacuum tube, then the transistor, to the integrated circuit and then the microprocessor. The IBM Corporation is to computing what the Ford Motor Company was to the automotive industry; it introduced and standardized affordable mass production. In the industrialized nations, most people have access to a computer at work or at home. Many even have laptops and / or mobile phones. The developing nations are also trying to bridge the digital-divide, which is expected to be easier to catch-up on than the industrial revolution.

Intel Corporation and Advanced Micro Devices Incorporation (AMD) are leading industry rivals that continually break the record for microprocessor speed with their respective products. The miniaturization of the computer is an obsession. This is demonstrated through the development of portable devices (PDAs), embedded systems, palm-tops, mobile computing, etc. The Tablet PC for instance, provides all the power of a standard notebook plus additional features that improve mobility including pen-input, light form-factors, handwriting and speech recognition.

The mainframe and supercomputing aspect is also vigorously pursued. Developed countries use supercomputers in a variety of industrial and economic fields. These are used to make financial and economic forecasts, to explore oil and gas deposits, to make weather forecasts and climate changes, to solve traffic problems in big cities, to administer logistics at large corporations, to perform various calculations for aerodynamics. They are also used in the pharmaceutical industry, human genetics, in astronomy, for controlled nuclear fusion, the modeling of explosions and nuclear tests and other complex or calculation intensive areas.

With performance almost double that of the Earth Simulator, in Yokohama, Japan, IBM's Blue Gene/L was recently ranked first on the Top500 list of the world's fastest supercomputers (PC World 2004). Not to be outdone, the Oakridge National Laboratory of USA (ORNL) is planning to build an even faster computer. Also, Russia has created a new supercomputing machine Skif K-1000, which is presently (December 2004) described as the most powerful computing device in Eastern Europe.

'Electronic mutation' is now a factor for the survival of several computer hardware components. For instance, the familiar Parallel port used for connecting Printers may soon give way completely to the Universal Serial Bus (USB) port. Flat screens are replacing the conventional monitor, radio and television tuning adapters have been developed for the PC. The computer has been adapted for both office and home use. It is not only a work tool or assistant but is also a multimedia entertainment centre for playing games, music and video. Better and cheaper PC accessories are released daily such as powerful speakers and web camcorders.

Software Progressions

A computer programming language is a formal notation for precisely describing and encoding algorithmic solutions to problems. An algorithm is simply a terminal, step-by-step procedure for actualizing a task. The major software that serves as the primary user-interface and controls the management of all tasks and system resources is known as the Operating System (OS). Other application software are mostly end-user utilities. From the punched cards of the Jacquard loom, programming has equally evolved with improvements in hardware design. Programmers have used Machine, Assembly and High Level (human like) languages. Different programming languages have constructs to support facilities needed for solving problems in specific domains. For example, COBOL has support for solving business related problems, C for systems programming problems, FORTRAN (and later MATLAB, LABVIEW, etc.) for scientific computing and, Lisp/Prolog for Artificial Intelligence applications. CADD-CIM software packages like AutoDesk's AutoCAD® were developed for integration with CNC machines. Although Apple Macintosh introduced software with graphical user interface (GUI), it was Microsoft Windows® OS and compatible products that proved more successful in the market place. Visual tools such as Microsoft Visual Basic®, Borland Delphi®, etc. were introduced for rapid application development. Hypertext Markup Language (HTML) and its new variants such as Extensible Markup Language (XML) and Wireless Markup Language (WML) were developed for accessing the Internet from PC and mobile devices. Lately, Sun Microsystems Java® has been touted as a more portable and robust development system.

There are two competing models in the software arena: proprietary and open-source solutions. Software (OS and other programs) that are copyrighted and offered (mostly commercially) under non-disclosure agreements is usually licensed by proprietary owners \ developers to end-users while those that are given out (mostly free) with accompanying source code for User modification are termed open-source. UNIX and Microsoft Windows® (and their derivatives) are the two dominant operating systems for which application programs are developed. Computing is being applied to virtually all areas of human endeavor such as communication, education, design and manufacturing, banking, commerce, entertainment, healthcare, sports, security, warfare, governance, weather studies and forecast, traffic management and transportation, outer space exploration, etc. The computer is one ubiquitous tool the modern world cannot do without.

Originally, computing was restricted to symbolic logic and the evaluation of mathematical expressions. In recent decades, new intelligent computational techniques, paradigms and applications have evolved such as Expert

Systems, Decision Support Systems, etc. For example, an expert system is an interactive-computer based decision tool that uses both facts and heuristics to solve difficult decision problems based on knowledge from an expert. Such knowledge is encoded using *If-Then* rules. There is also implementation of Fuzzy Logic (and reasoning), which is a scientific methodology for handling uncertainty and imprecision (Zadeh 1965). Fuzzy modeling gives a broader class of methods of granular information processing and knowledge representation. Another trend is Artificial Neural Networks (ANN). This is software that models the human process of learning and remembering. ANN involves a simulation of the human brain (consisting of multi-connected neurons) to model and predict the dynamics of an unknown system from sample sets of input-output data without explicitly determining the underlying relationships. ANN are trained by exposing them to samples, enabling them to recognize patterns. Also, the biological theory of evolution has inspired computational models such as Genetic Algorithm (GA) and its variants. A Genetic Algorithm is a directed random search technique that can find the global optimum solution in complex multidimensional search spaces. In this scheme, potential solutions constitute the population of the ecosystem, each individual member is manipulated (based on fitness criteria) by evolutionary operators to eliminate the 'unfit' and propagate the best ones. After several generations (iterations), mutated offspring converge to the solution (Gorzalczany 2002). Computational hybrids include the Neuro-Fuzzy systems, Neural GAs and, Fuzzified GAs, which combines the processing and predictive power of the various models (Pham & Pham 2001).

Peopleware Progressions

It has been suggested that the people who develop, manage and / or use the computer constitutes another important aspect described as *Peopleware* (Asaolu 2001). This takes cognizance of those that deploy and utilize computers as well as how they do so. The first computers were centrally located machines at specific organizations or research facilities. Access was naturally limited. With the miniaturization, reduced costs and mass production by IBM Corporation in the 1980s, more and more people have access to personal computers (PCs). Initially, software was designed to run on single PCs, with more users and the need for sharing of computing resources (such as files, printers, etc.) the issue of *networked* applications arose. The concept of a master machine (Server) to which others were connected and serviced (Clients \ Workstations) was implemented. While this proved successful, bottlenecks and limitations were soon discovered in this local networks or *intranets*. The US military and some scientists decided to create something much bigger and better that eventually evolved as the earlier described Internet. Although computer power, data storage, and communication continue to improve exponentially, computational resources are failing to keep up with what scientists' demand of them. A new technological adaptation is *Grid Computing* – this links and uses (dedicated or the idle time and processing power of) several participating computers on an intranet or the Internet to solve complex computational problems (BBC News 2003). By providing scalable, secure, high-performance mechanisms for discovering and negotiating access to remote resources, the Grid promises to make it possible for scientific collaborations to share resources on an unprecedented scale, and for geographically distributed groups to work together in ways that were previously impossible.

Other recent technologies include;

- *Short Message Service* (SMS) is the traditional e-mail of the wireless community. It has just been upgraded into Multimedia Message Service (MMS).
- *Bluetooth* is described by Ridgeway (2002) as embedded technology in electronic appliances; it is designed to create short-range wireless connectivity between separate devices. Stability within a noisy radio environment is achieved through a frequency hopping approach, which enables the module to avoid interference from other signals.
- *WiFi* or wireless fidelity is meant to be used generically when referring of any type of 802.11 network operating in the 2.4 GHz spectrum with a bandwidth of 11 Mbps. It is promoted by the Wi-Fi Alliance, a nonprofit international association formed in 1999 to certify interoperability of wireless Local Area Network products based on IEEE 802.11 specification.

Indeed, several consortia are proposing and implementing new methodologies / standards for wireless communication between electronic devices, for example in creating a network between a headphone, camera and printer or between a refrigerator, an ATM and a grocery store. While there is much speculation about the intelligence and capability of such new technologies, some functional applications are already commercially available. For instance, human language translation systems are a veritable area of research and, of recent has seen the deployment of mobile kits offering limited speech-to-speech translation.

Security Issues

There is also a lot going on for and against the dark sides of computing. *Bugs* are ancient but *Hackers, spammers, phishers, pharmers as well as spyware, virus and worm writers*, etc. are recent entrants into the computing vocabulary. Industry security experts and individual computer users strive to stay ahead of the next (potential) attack. Bugs refer to computer errors that were either undetected during hardware or software design or to known issues for which adequate work-arounds could not be proffered. Hackers break into supposedly secure computing systems usually for the fun of in or to steal information for espionage or merchandizing purposes. Spammers send mass (numerous) unsolicited e-mail to Internet users usually as a means of advertising. The situation reached such alarming proportions that in 2003, the US government passed the anti-spam law that makes sending unwarranted, assaulting and unidentifiable / misleading e-mails, illegal. Phishers create near-clones of financial or other commercial or governmental websites to trick and defraud unsuspecting people; they usually embed such website links in spam (e-mail). Pharmers are subtler, they "poison" or directly hijack local DNS servers by redirecting Web requests elsewhere –at times to a near-clone site. The browser is unaware of the diversion; the user may think the proper site is being visited and disclose personal information to identity thieves. Hookers or spyware developers create spy software and crawlers that automatically perform tasks and operations without the computer owners' permission; such as sending out information, displaying advertising or downloading data. Virus and worm writers produce destructive and self-replicating software that cram, slow down and eventually crash computer systems. Given all these, security is a big issue in computing with several firms and government agencies dedicated to countering the 'bad folks.' Operating System manufacturers together with computer anti-virus and *firewall* protection developers keep 'discovering and patching' dangers and security holes against which the industry must be protected. Also, privacy advocates continue to monitor developments in Biometrics application to prevent real and, imagined abuses. This is pertinent since Biometrics is the automated use of physiological or behavioral characteristics to determine or verify human identity. The financial, legal and other operational costs of computing faults and vices are enormous. Consequently there is increased research for better authentication, encryption and data processing algorithms.

Futuristic Devices and Applications

Now and in the future, hardware and software developers should build products that better support human needs and that are usable at any bandwidth. The old computing was about what the computer can do; the new computing is about what users can do (Shneiderman 2002). Though computers become more powerful and versatile, the knowledge and skills required to use it are easier to acquire and more accessible to the populace. Factors that facilitate groundbreaking and immensely successful or 'killer' applications include:

- A growing and aging population with shifting demographics
- Technology availability from continuously funded research
- Affordability / price
- Need (real or perceived)

Web browser based applications and wireless mobile computing might become the dominant forms of computing in the next decade, and proper support for it will require re-thinking several aspects of software design. We may not operate the paperless office until prolonged reading on the screen is pleasant to the eyes and more enriching than reading hardcopies. Who knows, humans may someday have embedded chips in our bodies to download, process and transmit information. The research for this is already on (Witt 1999). Eventually mankind could be self-wired as the '*last computer*.' The ban on physiological human cloning does not totally eradicate ethical problems if cybernetic organisms are allowed (embedding electronic systems in humans to create bionic or superhuman beings). From 3D modeling to simulation and virtual tours, man is devising smart devices for intelligent buildings, autonomous vehicles, and is working on producing more intelligent robots so that he could have time to embark on commercial space tourism and inter-planetary vacations. To this end, the record-breaking SpaceShipOne technology has been licensed by Virgin Airlines, this would facilitate commercial Space Travel by modified conventional aircraft (Microcom 2004).

Within the last few decades, contrasting enhancements were added to the home; for example answering machines for cordless telephones, the microwave for refrigerators, the all-in-one printer (fax, copier, photograph and document printer) for the computer, the VCR and DVD player for television, etc. In the not too distant future, the average person will possess more real, smart multifunctional utilities (car, phones, wrist-watches, etc.) than the presently seen special-effects artifacts in James Bond movies. With nanotechnology comes improvement in the production of synthetic organs, laser surgeries, wonder-drugs and the promise of increased and qualitative longevity. Centuries ago, those who thought of the possibility of space travel for humans or development of television like devices were accused of superstition and regarded as dreamers. These concepts are however, present realities. It might not be stupendous to await the day that telepathy or teleporty would leave the realm of science-fiction for real and everyday happenstance because mankind has neither discovered nor harnesses all the forces and laws in nature.

The impact of new computer technologies

All nations seek the production or adoption of new ICT that facilitate sustainable development. However, digital technology comes with its own downsides and risks. For example, unforeseen electric power outage (in developed economies) leads to chaotic or paralyzed situations while such failure lasts. It is a truism to acknowledge that computing advances and strengths are accompanied by corresponding levels of vulnerability. Developing countries are greatly benefiting from ICT not only from the deployment for social integration and educational purposes but also from commercial returns. India is the classic success story of creating wealth through 'outsourcing' – the offshore contracting of computing jobs to cheaper but highly skilled labor markets. New ICT have impacted the development of new economic paradigms such as just-in-time (JIT) delivery and TINA (there is no alternative to globalization and liberalization). Notable world bodies such as the UNESCO and several professional organizations are assisting nations, particularly developing nations to acquire or develop both the infrastructure and the expertise necessary for ICT. For example, Nigeria has received financial and material (in the form of ICT derivatives) aids worth millions of dollars towards the conduct of her proposed 2005 census. Also, Paradigm Lingua, the author's award-winning word-processor and translator for Nigerian languages has impacted electronic publishing in Nigeria (Asaolu 2003).

Funded, focused organizational or institutional research and development leads to new break-throughs, new patents, new products, new trademarks, new markets, new clients, new awards, etc. The competition is stiff but the rewards are often satisfying. However, not all new technologies are well received or become successful. A technology can only be described and its significance appreciated in the context of its uses and its users. New ICT means that fore-runners must create new standards, governments must introduce new regulatory practices (such as cyber law for Internet crime, copyright enforcement for protection of intellectual property, etc.), companies must re-train workers and acquire new products \ services especially if the existing system becomes inadequate, colleges need to revise curriculum and, consumers must make new choices. New studies would also normally be required to assess the environmental and sociological impacts. For individual workers in the ICT sector, advancement and perhaps survival is synonymous with continual skill acquisition (Acemoglu 1998). New occupations and job titles have been created. Even e-literacy or computer literary has become a prerequisite for job applicants in the developing nations. For researchers, sifting through materials from electronic libraries is a new daunting task, not finding those materials in the first place from physical libraries or ordering and waiting for paper prints! Homework, assignments and projects can be researched, written (typed) and produced (printed) on the computer desk at home, school or a business centre (cybercafé). This is facilitated by new web services such as Google® Scholar and Google® Answers from the developers of the Internet's most successful Search Engine. The former allows a free search of scholarly publications across various institutional and publishing repositories while the latter is a venture whereby 'Google® experts' provide answers to a subscribers' question for a fee.

Developers have realized the need to customize new ICT for various segments of the society. For example, there exist configurations of the PC as an office computer or the home computer and, their respective operating systems and software. Interestingly, this line can be thickened or thinned by the user who may decide to work from home (Venkatesh 1996). Children' access to new technologies is improving as they are targeted with recreational and educational products. There are also products specifically designed for the elderly to aid mobility and frail / failing body organs. Usage across gender is becoming equitable as more women are utilizing ICT products especially on the home front. Physically challenged individuals (e.g. the deaf or the blind) are now taken into consideration in the development of ICT product versions as equal opportunities are promoted in the society. Even prisoners have limited or regulated access to ICT services in most countries. The modern broadcasting media is highly sophisticated and has universal coverage and reach. Everybody is involved. At last, the world has become a *global village*.

Conclusions

All aspects of computer technology are dynamic. Innovations are reported almost on a daily basis from both academic and industrial players. Even the end-users contribute new ways of deploying existing tools. The World Wide Web and other Internet technologies serve to store and distribute such services and information. The prevailing technological challenge being addressed is making information and computing power accessible anytime, anywhere and on any device. A higher goal seems to be the development of a human-wearable chip or card that stores all personal information and can be used to manage all kinds of transactions on all computational platforms. Meanwhile, database systems on wired computers are giving way to knowledge base systems on wireless mobile devices. All these mean that data storage and processing must be more efficient and secure. Security issues are now a major concern because more interactions and transactions are effected daily, by more people adapting computing technologies.

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Designing Metacognitive Maps for Web-Based Learning

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ABSTRACT

This paper provides guidelines for designing metacognitive maps in web-based learning environments. A metacognitive map is a visual interface-based tool that supports metacognition throughout the entire learning process. Inspired by the four key metacognitive skills of planning, monitoring, evaluating, and revising, the metacognitive map is composed of two sub-maps (global and local tracking maps) and a planning space for learning processes/tasks. Metacognitive support is embedded within these visual on-screen maps and planning space.

Keywords

Metacognition, Web-Based Learning, Navigational aids, Visual Maps

Introduction

Web-based environments provide new potential to enhance learning through a visual and interactive delivery of instruction. When the Web is employed for instructional delivery, it can provide learners with a variety of diverse internet resources. Without the constraint of time and place, learners can thus search a wealth of relevant information; however, this abundance of rich learning resources can be detrimental for learners who do not possess strong self-regulatory and metacognitive skills to guide their discovery and learning.

Thus, the nonlinear nature of web-based learning environments is often disorienting to learners (Begoray, 1990). According to Tripp & Roby (1990) and Beasley (1994), learners are likely to suffer when disorientation increases. Conklin (1987) defined the disorientation as the tendency to lose the sense of direction and location in non-linear environments. Learning from hypertext requires that learners not only understand the text itself but also browse through the space selectively (Bolter, 2001). Learners must make navigational choices and constantly have to decide which node or link to select next. The navigational decisions that learners need to make while reading from hypertext may present difficulties and impose a higher cognitive load, especially on learners with low prior knowledge (Jacobson *et al.*, 1996). Therefore, one of the important differences in learning from hypertext compared to learning from traditional text is that learners need to understand the *structure* of the information space. It is not a surprise that visual-spatial skills contribute to learning from nonlinear websites (Baylor, 2001), given that understanding how different visually-organized semantic units relate to each other is critical for learners to make better navigational decisions.

Many researchers have studied and proposed methods for reducing disorientation within nonlinear environments. Some of the methods in these studies were concerned with embedding mapping, indices, and providing online guidance (e.g., Allison & Hammond, 1989). Other studies focused on ways to create the website more hierarchically (Jonassen, 1993). Still others considered metacognition when designing web-based learning environments (Lin, 1994). All of these approaches have pros and cons, which were considered in the design of the proposed web-based instructional tool.

The purpose of this paper is to design an instructional tool which can be used to overcome learners' disorientation and enhance their web-based learning experiences. This instructional tool is presented as a *metacognitive map*, including two sub-maps (a global map and a local tracking map) together with a planning space for learning tasks and processes.

Disorientation and Metacognition in Web-Based Learning Environments

In web-based learning environments, learning occurs through navigating information on the web. Sometimes learners experience disorientation in these nonlinear contexts. This type of disorientation is often observed in learning, and can notably limit instructional effects (Collis, 1991; Gay & Mazur, 1989). Specifically, such disorientation can require a longer time for learners to complete their task and distract them in the process.

On the other hand, orientation can be described as the ways by which learners are able to recognize their current position and next direction. Oliver and Herrington (1995) suggest that the orientation can be supported by providing such cues as path trails (or "breadcrumbs") and simple graphics presenting position. It is believed that they can assist learners significantly even though the amounts and spaces of aids to screen presentations are small. Likewise, the metacognitive map proposed here can similarly support learners' orientation within the learning content.

As already mentioned, metacognition depicts learners' cognitive sense of how they understand the given information and what should be done to control or regulate their cognitive processes (Puntambekar, 1995). It is mentioned that there are two important sides of metacognition (Brown, 1987). *Awareness* about cognition and learning is the one of important aspects of metacognition, and the second is *control or regulation* of these cognitive processes. Learners need metacognition when they judge what should be done and where they should go with overcoming perceived shortcomings (Balajthy, 1990).

The levels of metacognition exhibited by the learners were wide ranging. Learners who have a high level of metacognition mainly show several metacognition skills such as flexible planning, continuous monitoring of learning process and thoughtful evaluation of ones' own cognition (Oliver & Herrington, 1995). Also, they can appropriately connect the given task with their own skills or strategies to deal with the task (e.g., Kunz *et al.*, 1992). However, learners who have a low level of metacognition tend to become disoriented in the web-based learning environment. They are likely to forget what they have to do and where they need to go for their next tasks. In this situation, the level of metacognition and disorientation appears to be closely related (Land, 2000; Tabatabai, 2005; Chambers, 1999). Overcoming this disorientation through metacognitive support is thus a primary goal when designing web-based learning environments.

The Underlying Metacognitive Principles of a Metacognitive Map

There are several definitions of metacognition. Flavell (1987) defined metacognition as the ability to understand and monitor one's own thoughts and the assumptions and implications of one's activities. Brown (1987, 1978) described metacognition as the degree to which learners are engaged in thinking about themselves, the nature of learning tasks, and the social contexts. She also described metacognition as being comprised of activities for regulating and monitoring human learning.

According to both Flavell (1979) and Kuhn (2000), metacognition is composed of both metacognitive knowledge and metacognitive regulation. Here, metacognitive knowledge is described as knowledge which is used to manage thinking processes. Besides, the metacognitive knowledge is separated by three parts: knowledge of person variables, task variables, and strategy variables (Flavell, 1979). While Flavell (1987) focused on metacognitive knowledge, Brown (1987) emphasized metacognitive skills or regulations, and defined metacognition as an awareness of one's own cognitive activity; the methods employed to regulate one's own cognitive processes; and a command of how one directs, plans, and monitors cognitive activity. Stated differently, metacognition is made up of active checking, planning, monitoring, testing, revising, evaluating, and thinking about one's cognitive performance (Baker & Brown, 1984). Metacognition begins in an unconscious mode and is followed by increased conscious regulation and self-monitoring in the use of strategies, knowledge, and the acquisition of new knowledge (Brown & DeLoache, 1978). Brown (1987) specifically delineated four components of metacognition: 1) planning, 2) monitoring, and 3) evaluating, and 4) revising. These factors of metacognition are described next.

First, planning refer to the deliberate activities that organize the entire learning process. These planning behaviors consist of establishing the learning goal, learning sequence, learning strategies, and expected learning time. Secondly, monitoring refers to the activities that moderate the current progress of learning. For example , learners can ask themselves questions as follows: "what am I doing," "am I on the right track," "how should I do," "what information is important to complete the given tasks," "should I do with different perspectives," "should I adjust my pace depending on the difficulty," etc. These monitoring activities are conducted typically during the learning activities. Third, evaluating one's own learning processes involves an assessment of the current progress of the activity. This systematic method of evaluation can assist learners with developing the necessary skill sets and strategies from which they can draw in novel situations where it may become applicable. Fourth, revising one's own learning processes involves modifying previous plans regarding goals, strategies, and other learning approaches. In web based learning environments, learners need to be able to create relevant and effective plans that reflect their self awareness of their skills and an understanding of the task requirements. The learners should be self-regulated so that they can monitor their learning process, evaluate their processes by themselves and select appropriate learning strategies to effectively complete assigned tasks through their own metacognition process.

Although metacognition and its constituent elements are defined differently, depending on the researcher, the definition of metacognition as an awareness of one's own cognitive activity is commonly accepted. Also, Brown (1987) places an emphasis on metacognitive skills rather than metacognitive knowledge to improve learning outcomes, because metacognitive skills are more practically employed. The next section describes how these four key metacognitive skills (*Planning*, *Monitoring*, *Evaluating* and *Revising*) are supported through the design of a metacognitive map.

The "Map" aspect of a Metacognitive Map

A map is a generally used navigational aid to reduce learners' disorientation in web-based learning environments; such knowledge-based maps can also be developed by learners as a way to facilitate their understanding of the nonlinear content (Lee *et al.*, 2005). Generally, a map helps learners navigate the learning content by providing a visual structure consisting of nodes and links that represent the learning components and their relationships. Although there are several types of navigational maps (e.g., global map, local map, local tracking map, and fish-eye view), this paper focuses on the use of a global and local tracking map as constituents of a metacognitive map. The global map and local tracking map are classified by the scope of the presentation of the learning content. Specifically, the *Global Map* is used to outline the structure of the entire learning content, and to guide learners to plan their activities more effectively. The *Local Tracking Map* is used to support learners to check what they have already done and to more easily judge what they need to do. Moreover, the *Planning Space* provides a mechanism to support learners' premeditated planning of the learning tasks. In consideration of the potential for learners' cognitive overload, the metacognitive map is devised as an embedded tool within the learning environment. A suggested interface for the metacognitive map is provided in Figure 1 and the functionality of the frames is described in Table 1.

A. Learning Contents	**B. Global map**
	C. Local Tracking Map
	D. Planning Space

Figure 1. The Frames of a Metacognitive Map

Next, an interface that applies these principles into the context of "intellectual property" is illustrated and described. As shown in Figure 2, learning content is presented in the left side of interface, while the global map, local tracking map, and planning space are displayed on the right side of the interface. Learners are expected to set their learning goals, learning strategies and expected learning time in the planning space. For example, as their learning goals, they may select "I choose to learn the content of intellectual property based on the four case studies" or 'I will find out the types and characteristics of intellectual property." Also, the learners can set their expected learning time (e.g., 20 or 30 minutes) to complete the current learning goal. Likewise, they can choose their desired learning strategies such as note tasking, mnemonics, diagramming, or compare/contrast of the content.

The overall flow of the system is as follows. If a learner clicks one of nodes on the global map, the content in the left side will show the appropriate content. Whenever learners click a node on the global map, the node will be added and decomposed within the local tracking map. In this way, the global map, local tracking map, and the planning space work together in synergy.

Table 1. Descriptions of Metacognitive Map Components

Components	Description	Metacognitive Support
Learning Contents (A frame)	The current learning content is presented in this frame.	N/A
Global Map (B frame)	The overall structure of the learning content is represented in the form of global map, similar to a site map.	*Planning* The global map facilitates learners in planning their learning from a holistic perspective, facilitating them in planning study time and setting priorities. *Monitoring*

		Learners can monitor their learning processes based on the global map by checking how much they have completed relative to the entire content of the site.
Local Tracking Map (C frame)	Whenever learners click a content area of the global map (B), a new sub-node is generated.	*Monitoring* The local tracking map supports learners to check what they have already completed/learned and to more easily judge what they need to do next. *Evaluating* With the local tracking map, learners can evaluate and think about their performance and how well they have achieved their initial goals. To evaluate their learning, they can refer to their initial plan in the planning space (D).
Planning space (D frame)	This space is for premeditated planning of learning tasks. It consists of three parts; learning goal, learning strategies, and expected learning time. All of these parts are revisable at any time.	*Planning* Learners can check their learning goal, expected learning time, and learning strategies in this space. The global map (B) will be referred to, in support of planning for learning. *Revising* This space can be revised by learners at any time based on their ongoing monitoring and evaluating of their learning. The intent is that learners will adjust their behavior according to the updated plan.

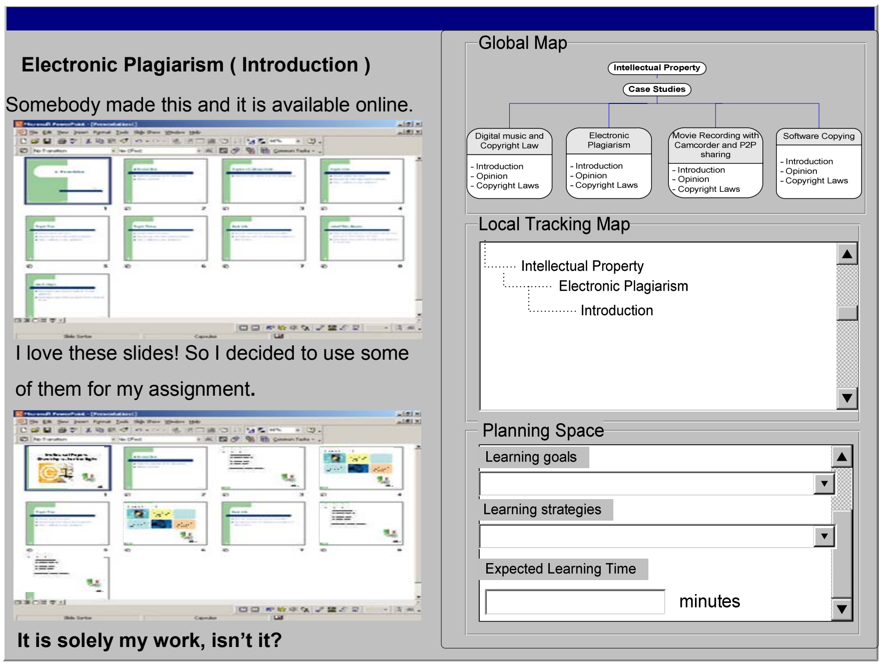

Figure 2. An Example of Metacognitive Map

Conclusions

Inspired by the four key metacognitive skills of planning, monitoring, evaluating, and revising, the metacognitive map is designed as a visual metacognitive support tool. The ultimate goal of this tool is to support learners' metacognitive activities to facilitate their orientation within web-based learning environments. With the metacognitive map, learners are expected to perform both cognitive and metacognitive activities effectively and efficiently. This is supported visually through the maps (global map and local tracking map) and planning space which works in synergy. While the map is theoretically grounded, the next step is to empirically evaluate the effectiveness of this support tool as it impacts metacognition and learning.

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Content Classification and Context-Based Retrieval System for E-Learning

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ABSTRACT

A recent focus in web based learning systems has been the development of reusable learning materials that can be delivered as personalized courses depending of a number of factors such as the user's background, his/her learning preferences, current knowledge based on previous assessments, or previous browsing patterns. The student is often confronted with complex information mining tasks in which the semantics of individual sources require a deeper modelling than is offered by current learning systems. Most authored content exist in the form of videos, audio, slides, text, and simulations. In the absence of suitable annotations, the conversion of such materials for on-line distribution, presentation, and personalization has proven to be difficult. Based on our experiences with Open Courseware (OCW) and Singapore-MIT Alliance (SMA) video database, this paper presents a personalized delivery system that uses a domain ontology and pedagogical models to compose course materials in response to a user's query. We also present several important E-learning applications emerging from the framework.

Keywords

Semantic analysis, Multimedia features, Video indexing, State diagram, Contextual retrieval, User model

Introduction

E-Learning is rapidly changing the way that universities and corporations offer education and training. In recent years, the acquisition and distribution of rich media content has been largely automated, however research challenges still remain for the dynamic creation of media productions for the end user experience (Kinshuk and Lin, 2004). Prerequisites for reusing prepared learning materials typically involve finding relevant documents and context based retrieval of content elements which we will refer to as lecture fragments (Vercoustre and McLean, 2005). The following issues become crucial in reusing materials in context based learning:

(a) Finding relevant document sources within the context of recent topics learnt and of the nature of audience.
(b) Selecting more specific parts of documents that could be reused, based on the pedagogical semantics of definitions, examples, graphics, tables, and images.
(c) Defining the sequence in which document elements for selected concepts should be accessed or presented
(d) Defining the curriculum planning that would fit with the pedagogic approaches, and that will hopefully adapt to the actual learner.

A generic approach to handling such issues is to define reusable chunks of documents that can be retrieved, adapted, and assembled in a coherent way for a given educational purpose (Fundulaki et al., 2001). Unfortunately, the way fragments are described and used is very much system and application dependent. Therefore it cannot be reused by another system for another learning experience on the same topic but with a different objective, or a different instructional method. Most often the fragments have to be written from scratch with the particular application in mind. In this paper we address the issue of defining and automatically classifying the semantic fragments.

Much of the e-learning materials that have been created in recent years are in raw form as audio, video, slides, text and simulations. Manually annotating this content with semantic labels is a laborious and error prone task. Semi-automatic tools are therefore sought that can perform analysis on these materials and provide semantic descriptions. In this paper, we present a framework to analyze information in varied resources and discuss how fragments can be contextually (re)used for personalized learning. We show how the efficient retrieval in complex domains can be done by a two stage process of assigning semantic labels to media content and resolving user queries through mediation between pedagogical models and domain models.

Importance of Context-Based Retrieval (CBR) system for e-learning

A key problem exists in bridging the semantic gap between raw video and high level information required by students. For example, what sort of information can we extract from raw video, audio, and slides and how to extract them? What can we understand from the information? How to put the information into appropriate form so that it can be customized for use by other applications? Referring to a course on computational algorithms in the computer science domain, a student reviewing for an exam poses the query "What is the relationship between Dynamic Programming and Greedy Algorithms?". A straightforward technique involving keyword search is not effective as the terms dynamic programming and greedy algorithms may not appear in the same local context. In addition, there is no such index available in video database for providing answers to semantic queries.

The direct application of text mining tools or natural language processing tools on an e-learning text database would not, in general, yield a meaningful index. This is because the traditional techniques of keyword identification and hot spotting of concepts do not work well when the query is mostly semantic in nature. Additionally, the target keyword or abstract concept is likely to occur many times within a course, thus contextual knowledge is required to refine access to the information. Furthermore, student learning is impeded by the lack of a video index that currently makes the tasks of browsing and retrieval highly inefficient. The construction of a video index is a tedious task when done manually. Content based solutions are available for other media intensive domains including sports and news, but have not yet been systematically explored for educational videos (Idris and Panchanathan, 1997; Woudstra et al., 1998; Mittal and Cheong, 2003). The key contributions of this approach are:

1. Classification of semantic level events from the event flow of the lecture video.
2. Use of a rule based system to conduct inference and discover relations in the space of potential presentations.
3. Formation of a base for providing personalization tools for various users.

The paper also shows how the material once developed can be reused in context of the type of user and learning mode of the user. Using our technique, we are able to separate the lecture videos into several component states and personalize the video presentation from these states. For our experiments, we used a corpus of 26 lecture videos from the Singapore-MIT Alliance along with the associated PowerPoint slides.

Organization of the paper

This paper describes an automatic methodology for the indexing of the lecture videos. The second section described the distance learning paradigm, and the problems faced. The third section discusses the formulation and analysis a of state model for lectures. In the fourth section, video indexing features are discussed. The section titled of Lecture Video Indexing elaborates on the mapping of low-level features to lecture semantics. Finally, we discuss the experimental results, several applications and significance of taking this approach, as well as examine the future direction of this research.

Distance learning Paradigm

Issues in Designing CBR for Distance Learning

Indexing in the present context means labelling the content into semantically meaningful units corresponding to the different topics and ideas that a lecturer has introduced (Semple et al., 2000). Extracting the content of the lecture allows students to identify the underlying structure of the lecture and easily access the parts in which they have the greatest interest. In traditional books and textual documents, the organization of the learning material is decided by the author and the learner is expected to read the document linearly, although nothing prevents him to jump to the conclusions first or to skip a section if he is already familiar with the concepts. The flexible nature of hypertexts and on-line materials offers new opportunities and challenges for learning support that can guide the learner in a more personalized way. In particular, when the content is split into smaller units, the learning system is expected to provide some guidance as to which part to read next based on prior knowledge of the user and nature of the user.

Related Work

Using video for educational purposes is a topic that has been addressed at least since the 1970s (Chambers and Specher, 1980). Recently the focus of the research has been to maximize the utilization of educational video resources which have accumulated over a period of time. Ip and Chan (1998) use the lecture notes along with Optical Character Recognition (OCR) techniques to synchronize the video with the text. A hierarchical index is formed by analyzing the original lecture text to extract different levels of headings. An underlying assumption is made that the slides are organized as a hierarchy of topics, which is not always the case. Many slides may have titles which are in no way related to the previous slide.

Bibiloni and Galli (2003) proposed a system using a human intermediary (the teacher) as an interpreter to manually index the video. Hwang et al. (1997) propose a hypervideo editor tool to allow the instructor to mark various portions of the class video and create the corresponding hyperlinks and multimedia features to facilitate the students' access to these pre-recorded sequences through a web browser. This scheme also requires a human intermediary and thus is not generalized.

The recently developed COVA system (Cha and Chung, 2001) offers browsing and querying in a lecture database; however, it constructs the lecture index using a digital text book and neglects other sources of information such as audio or PowerPoint slides.

Temporal state model for lectures

The integration of information contained in e-learning materials depends upon the creation of a unifying index that can be applied across information sources. In content based retrieval systems, it is often convenient to create a *state model* in which the nodes represent semantically meaningful states and the links between nodes represent the transition probabilities between states. In the case of educational video information systems the state model for the lecture is composed of states that represent the pedagogical style of teaching. For the purpose of illustrating the concept, let us consider computer science courses, especially theoretical ones like the Introduction to Algorithms. In this case, each lecture can be said to contain one or more topics. Each topic contains zero or more of the following pedagogical elements:

- Introduction – general overview of the topic.
- Definitions & Theorems – formal statement of core elements of the topic.
- Theory - derivations with equations and diagrams.
- Discussions - examples with equations and diagrams.
- Review – repetition of key ideas.
- Question and Answer – dialogue session with the students.
- Sub-Topic – branch to a related topic.

A simple state model for video based lectures can be represented as shown in the Figure 1. Machine learning techniques are used to construct a state model consisting of 8 different states linked by maximal probability edges. Each edge from a given node represents the probabilistic transition to another state. For example, from state Topic, the next state is Definition with probability 0.91 and the next state is Discussion with probability 0.09. The edge labels in Figure1 show the transition probabilities using the corpus of SMA lectures as a training set.

The state model implicitly encodes information about the temporal relationships between events. For instance, it is clear from Figure 1 that the introduction of a topic is never followed by a *theorem* without giving a *definition*. The state model when supplemented with our indexing techniques (discussed in later sections) provides useful information regarding the possible progression of topics in the lecture.

The semantic analysis of raw video consists of four steps;

1. Extract low and mid level features. Examples of low level features are color, motion, and italicized text. Some mid-level features are zoom-in and increased hand movement of lecturer.
2. Classify the feature vectors from the lecture into a finite set of states. The resultant states correspond to salient events in the lecture and are assigned semantically meaningful labels, such as Definitions, Emphasis, Topic Change, Q&A, and Review.
3. Apply contextual information to the sequence of states to determine higher level semantic events, such as *defining a new term*, *reviewing a topic*, or *engaging in off-topic discussion*.

4. Apply a set of high level constraints to the sequences of semantic events to improve the consistency of the final labelling.

Semantic analysis of the video begins with the extraction of salient features. Features are interpretation independent characteristics that are computationally derived from the media. Examples are pitch and noise for audio and color histogram and shape for images. Quite a number of features have been identified and many feature detection algorithms already exist (Gonzalez and Woods, 1992; Gudivada and Raghavan, 1995).

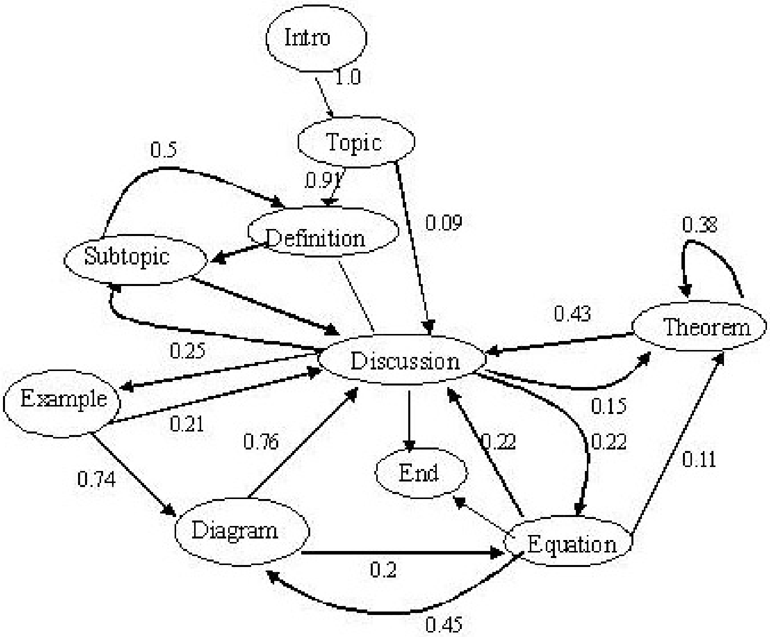

Figure 1. State Diagram of Lectures - Each state follows the probabilistic edges to go to another state

Video Indexing Features

The evaluation of algorithms used in video segmentation engines and the detailed mechanisms for feature extraction are beyond the scope of this paper. Rather we will present a list of the most useful features for audio, video, and text that are used in the video indexing arena. We then discuss some indexing techniques that are based on these features.

Audio features

There are many features that can be used to characterize audio signals. Volume is a reliable indicator for detecting silence, which may help to segment an audio sequence and to determine event boundaries. The temporal variation in volume can reflect the scene content. For example, a sudden increase in volume may indicate of the transition to a new topic. Spoken word rate and recurrence of a particular word is an indicator of the scope for a topic or cluster of words within a discussion (Witbrock and Hauptmann, 1997).

Video Features

A great amount of research has gone into summarizing and reviewing various features useful for the video segmentation (Wang et al., 2000). Some of the most common features used in video analysis are discussed below. The color histogram, which represents the color distribution in an image, is one of the most widely used color features. If the difference between the two histograms is above the threshold, a boundary shot is assumed. Motion is an important attribute of the video. Motion information can be generated by block matching or optical flow techniques (Akutsu et al., 1992). Motion features such as motion field, motion histogram, or global motion parameters can be extracted from motion vectors. High level features that reflect the camera motions such as panning, zooming and tilting can also be extracted (Rui et al., 1999). Motion features such as hand velocity, hand position, black board motion, pointing gestures, etc. inherently store much information.

Text Features

In the distance learning paradigm, text is one of the most important features that has still not been extensively researched and utilized. Ip and Chan (1998) propose text assisted video content extraction, but only to synchronize the video with the text. Text in the form of PowerPoint slides, which generally is the case with the educational videos inherently stores a great deal of information as we shall see with the SMA lecture corpus.

Lecture video Indexing

We introduce a general framework for video indexing systems in this section. The first step is to extract features and information from the raw data, which in this case are the video and the lecture notes. The most important and basic step in a video indexing engine is to extract the right features and then combine these to get the most efficient indexes.

Deriving semantics from low-level features

The mid level video features such as camera zoom or switching between the speaker and audience when used alone can not be reliably associated with topic change. However, when used to supplement other features they may provide important discriminatory information. The audio features such as detecting a silence may help to determine the beginning and end of salient moments in the lecture but certainly not the occurrence of a topic change. It does help to identify a question and answer session with the back and forth switching of audio from teacher to student. But these features are not sufficient to extract the different topics and their interrelationships as presented in the lecture. The potentially richest source of structural information is the black board activity, which in turn is represented in the lecture notes. Thus a proper analysis of the lecture notes, that is, the PowerPoint slides along with the properties discussed below can indeed be used to identify the lecture structure.

The PowerPoint slides that serve as lecture notes inherently store important information regarding the lecture which is still largely untapped. The text formatting information in the form of font size, shape, color, and boldness in itself reveals important aspects of the lecture. The state model of the educational videos discussed earlier includes four basic categories that also apply to slides, namely: Definitions and Theorems, Examples, Proofs, and Formulae. Analysis of the SMA lecture corpus prior to the computer based indexing identified a set of formatting rules in the PowerPoint slides such as: all the important words (keywords with definition) are always red and in italics; the special names are always in quotes; the slides having an example always have a word "example" in it; the questions and FAQs have a question mark in the particular slide; the common names are always in square brackets, etc. Some video feature such as, camera zoom in or zoom out to the blackboard or to the audience also specify transition of the lecture from one state to another say from Diagram to Discussion state. These rules may be specific for the SMA courseware, but the broader picture says that we can similarly define a set of rules existing in a large corpus of distance learning coursewares. This is then synchronized with the video to get the exact clip. The rules for indexing the slides in the above mentioned four categories can be summarized in the following categories.

Category 1: Definitions / Theorems

The keywords or defined terms are always red and in italics.. The word *definition* or *theorem* may be present and the string queried has to be definitely found in the slide.

Category 2: Examples

The course under consideration for the Introduction to Algorithms has an associated image file for all the examples to represent special graphics or equations. The presence of the text pattern for *examples* or *examples:* along with the string queried is mandatory for a slide to qualify as one containing examples. When analyzing the text, the context of the current slide is related to the previous slides. Thus the context of the particular example is linked to the contents above it and the topic in currently being discussed.

Category 3: Proof

The word *proof* along with the string queried is assumed to be present in the slides having relevant information associated with the query. This assumption is a generalized one and can be used for all distance courseware.

Category 4: Formulae

Slides containing embedded formulae can be easily identified through the identification of special symbols used to represent the mathematical expressions. Queries for mathematical expressions can be simply resolved by converting the query expression into a string of characters then performing pattern matching.

Sometimes a slide may contain only examples without any reference to the topic, as they might be in continuation with the previous slides. In such cases the system looks for the keywords queried in the previous slides and thereby checks for the presence of context in which the examples are given.

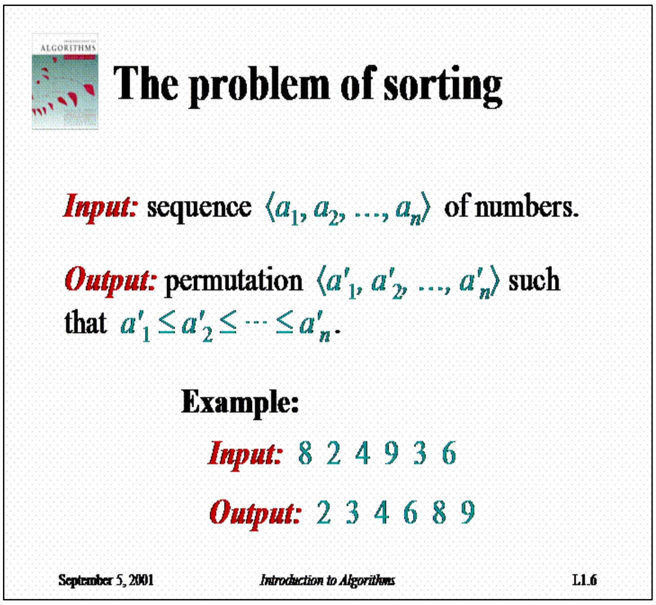

Figure 2: An example of the definition of a concept. Note that there are no words related to 'definition' such as define, etc. in the slide

It is well known that video features taken in isolation are highly ambiguous. The video feature for *zoom out* may indicate either discussion in the class, the presentation of a definition, or simply a technique to reduce the tedium of the video. Similarly, we find that the video feature *zoom in* may indicate the occurrence of Topic, Example, Diagram, Theorem, or Equation states.
After the entire lecture has been classified, the labelled metadata can be used to perform multiple tasks. The first one is searching in context. Several automatic frameworks exist for searching in context. For an example, see (Mittal and Altman, 2003). Here we employ a simple contextual searching algorithm. To enable searching in context, we need to manually enter the topic names for each video clip associated with a significant pedagogical event previously identified by the application of the classification rule set. Once the topic names have been keyed into the topic lists, we can then perform contextual search just by searching for all occurrences of the queried subject and returning the results.

This method is accurate because under our definition of the topic state, all subject matter which is important enough to be explained separately is classified as a topic or a subtopic. For example, when the term *quicksort* is mentioned under the divide-and-conquer method, our system classifies *quicksort* as a subtopic. Again, when *insertion sort* is compared with *quicksort*, it classifies *insertion sort* as another subtopic. As a result, the topic list is comprehensive in covering all material which is of importance. Hence, we are able to retrieve all instances of a particular query by searching through the topic list.

Synchronization of the video and the retrieved slide

Analysis of the blackboard for characters or the speech for words is performed to find a cluster of words which can be matched with the corresponding cluster of words in the PowerPoint slide. Initial experiments using Optical Character Recognition techniques for blackboard text showed that the efficiency is quite low and it is highly dependent on the lecturer's handwriting. Recent experiments with the speech recognition system seem to be more promising and can be used for alignment as well as keyword detection (Witbrock and Hauptmann, 1997). For effective video search, one needs to know exactly when each word in the transcript is spoken. A speech recognition system can provide this information. Thus, synchronization of the video and text can be achieved The key idea is to create a system which automatically segments the educational videos which the students can then use to explore the desired sections of the lectures without going through the linear search. Thereby saving time and effort required of the student.

Experimental Results and applications

We tested our method on 26 lecture videos from the Singapore-MIT Alliance course SMA5503. The semi-automatic classification results are tabulated in Table 1

Table 1:Experimental Results in Confusion Matrix. The high value at the diagonal entries denotes the high accuracy in detection of that state

Actual State	Detected State							
	Intro.	Topic	Defn.	Discn.	Theorem	Example	Eq.	Diag.
Introduction	100							
Topic		90		5.5			2.25	2.25
Definition		20	80					
Discussion		7		86	3.5		3.5	
Theorem		6.25		6.25	87.5			
Example		8.5		8.5		83		
Equation		13		25			62	
Diagram			7.7					92.3

Overall, our method has an accuracy of 85.1% in detecting the correct state. The personalization rules being dependent on the first algorithm also have an accuracy of 85.1%. The contextual searching algorithm is solely dependent on the correct classification of the Topic State and, therefore, has an accuracy of 90%. In figure 3, we present some possible fields that must be stored with each fragment. The utility of some of these are obvious while the others are used in the following applications:

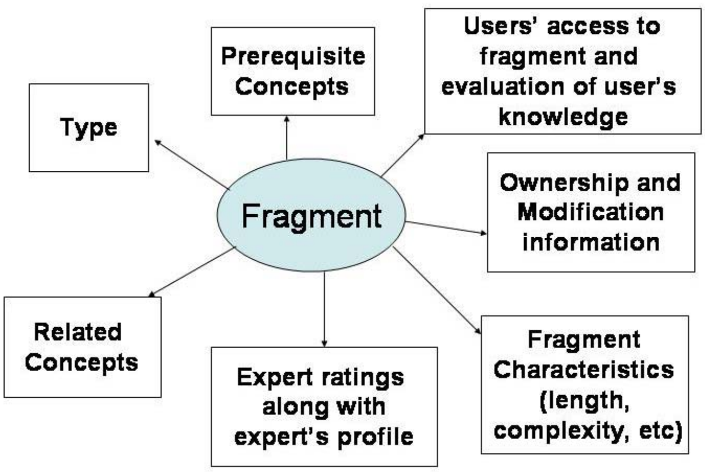

Figure 3: The fields stored with a fragment. The fields are updated when the fragment is created, accessed or rated

Personalization

A lot of research has been dedicated to develop flexible learning material that can deliver personalised courses depending of a number of factors such as the user's learning preferences, his current knowledge based on previous assessments or previous browsing in the material (Sampson et al., 2002). We are able to create several broad categories into which we can segment our target audience. This way we can ensure that the content for an absolute beginner is not the same for that of a student preparing for his exam. The students interested in this courseware can be divided into three broad categories on the basis of their requirements to review the lecture as follows; (a) A student may be viewing the lecture for the first time, (b) a student maybe reviewing it to brush up on concepts, or (c) a student may be reviewing it for the preparation of examination. Amongst these students some may prefer to view only the video part where, there is an example or a definition for a particular topic that is, he/she would like to view the lecture from the perspective of a particular topic. Some of the students may be interested in reviewing only the proofs in order to prepare for the examinations. The student is required to give a keyword for his search, using this keyword the search is performed and the search results are categorized under the four mentioned categories and presented to the student. Depending on the requirement and the available result set the student selects whether he wishes to review definitions, examples, formulae, proofs, or he wishes to review all one by one. The appropriate video along with the slides under the specified category is then provided to the student. If the information is found more than one time in the lecture, the system identifies these parts of the lecture as correlated to the searched topic and thus presents these topics under the head of related topics category to user.

An interesting presentation style would be to consider the user model, his learning objective and contextual information. Table 2 presents a set of rules that could be useful in personalizing the content. The fields in Table 2 with each fragments help determine the prerequisite concepts, type, etc.

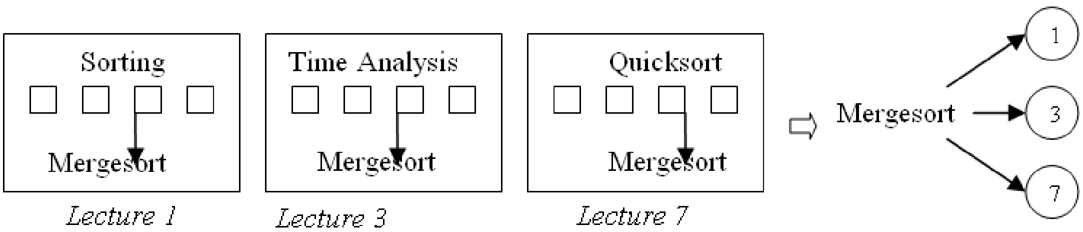

Figure 4: Search for "Merge Sort". The occurrence of merge sort in three different lectures is determined. Appropriate context would then be used to find out whether the reference is a discussion on sorting, time analysis, or comparison with Quicksort

Summarization

There are many occasions where students are interested in obtaining a summary of the lecture. Summarization of the lecture should be based on the semantics of the lecture video. This can be done in several ways depending on the requirements of the student. Consider a simple and yet very important application of summarization where a student wishes to decide upon registering for the next semester course based on the summary of the course. Just as a movie trailer effectively portrays the type of movie (say violence, action, suspense, etc.), the summarization of the course should be representative of the degree of difficulty, level of mathematics, lecturer's abilities, etc. The flexible selection of content is easily accomplished since metadata for the characteristics of each fragment is stored in a database. The fragment whose characteristics are most common to those of other fragments can be included in the summary. In addition, an important consideration is also to include fragment of each type (such as question-answer session, lectures, etc.).

Another way of presenting summarization is as follows. Give the contents of the lecture, slide by slide, under the respective slide title. Under each slide title the important points covered in that slide are sited. Using this as a cue the student can link to the appropriate part of the lecture and view the video. Though this in itself will generally be a huge list, it serves the purpose of giving an idea of the contents of lecture as well as relative position. Thus, eliminating not only the linear search but also giving an idea of the breadth of lecture. Secondly, a student may wish to prepare for an examination by just going through definitions and the corresponding examples or by going through definitions and proofs.

Table 2: The adaptive presentation style depending on user model and contextual information

User Type	Contextual Learning model	Desired information	Presentation Style
Biology student	Concept searched as part of another course (biotechnology)	Divide and Conquer	(a) Present definitions & examples (b) Give links to prerequisite concepts (c) Skip theorems and mathematics
Researcher	Terminology/Concept clarification	Strassen's Algorithm	(a) Present definitions, analysis and theorems (b) Relate to places where Strassen's algorithm is used or related, for example, divide-and-conquer
Student beginning the course	Serial coverage	Everything in a lecture	(a) Provide links to skip theorems and analysis (b) Show the general flow of the lectures and the fragment in the entire course to gather synthesis
Student revisiting the course	Exam preparation	Entire course	(a) Relate to discussion and QA session (b) Show related concepts

Retrieving fragments of documents

We are able to efficiently and accurately search in context throughout the video database. For example, by searching for merge sort, we return not only the video clip that teaches merge sort, but also other clips from other lectures where some aspect of merge sort is further explained (see figure 4). In this particular case, merge sort is mentioned in video lecture 1 under the topic Sorting. It is also mentioned again in lecture 3 under Time Analysis, and in lecture 7 where it is compared to quicksort. Hence, when a student uses this system to search for merge sort, he has immediate access to all three related video clips even though they are taught in completely different lectures and different parts of the course. As a result, a student searching for merge sort will get a much clearer idea of how it actually works and all its different aspects.

When users are looking for documented information, expert finding systems can provide useful evidence as to the quality of the information as (Höök et al., 1997) report, saying that a user of a collaborative filtering system may be more interested in what particular experts regard as important information.

Finding experts

Quite often in a collaborative environment, the students wish to know if they could get some directions from someone understanding a particular concept. Matching a learning need to a person that can provide a solution or advice can be supported by finding relevant people based on their expertise as computed by analyzing the fragment of the documents they produce, own, read etc. This is accomplished by keeping track of which user accessed which fragment, along with the assessment by the system on user's understanding of the fragment (through evaluation, FAQs, discussion forum, etc.). This is illustrated in Figure 3.

Conclusions

We have designed a system for indexing videos using audio, video and PowerPoint slides and segmenting them into various lecture components. Personalized documents for use in educational systems enable the presentation of fragments based on the user model and rich semantic descriptions of the fragments. This helps to make the videos more suitable for absorption of the subject matter by the students. While full-text indexed retrieval systems have been proposed earlier, our method is more efficient as it uses all forms of media to segment and index the video. It also allows us to perform efficient contextual presentation with minimum human supervision. The system allows better reuse of the fragments for different purposes. For future work, better rules can be created to handle more diverse categories and to make the personalization tailored to individual needs.

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Hu, B.-Y. (2006). Book review: Integrating technology into higher education (M. O. Thirunarayanan and Aixa Perez-Prado). *Educational Technology & Society*, 9 (1), 359-360.

Integrating technology into higher education

(Book Review)

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The educational fields such research or teaching practices have been changed so rapidly while technologies are able to offer effective assistances. Integrating technology into instruction not only supports the implementation of high-quality instruction but also explores new issues in higher education. Despite different technologies have been used so widely in many fields, the main issue aims to how to make integrating models successful. Indeed, integrating technologies into higher education are based on two fundamental criteria. One is whether technology enhances learning or not; and the other one is that different integration models are required to explore for fitting pedagogical practices across diverse disciplines. Technology integration creates an alternative opportunity with high challenges that foster the pedagogical orientation from instructor-centered to learner-centered instruction.

"Integrating technology into higher education" is a collection of articles by different authors**.** It covers a comprehensive range of topics and consists of 20 chapters contributed by innovative application at higher educational settings. Those chapters cover 4 themes: infrastructure, instructional design, integration, and interaction. This book provides many new ideas and lessons learnt from their experiences to help instructors and administrators. The potential readers might be persons who eager to apply technology integration models or who concern about the problems and reflection regarding technology integration. It describes a comprehensive review on the state of art of technology at higher education levels. Most cases in this book gain positive feedbacks from both learners and instructors because technologies meet their needs, which are not so easy-to-get in traditional classroom-based and instructor-led instruction.

The book aims at the success and stumbling blocks faced and overcome while technology integration has been implemented at higher education levels. Issues regarding infrastructure, instructional design, integration, and interaction are interwoven in every chapter of this book. Firstly, infrastructure discusses what is in and outside instructors' control while incorporating technology into the classroom, which also offers suggestions on how instructors can gauge infrastructure support at their institution. Secondly, instructional design demonstrates the construction of the course content, learning activities and assessment. Thirdly, integration presents the attributes of media and the presentation of teaching models. Fourthly, interaction deals with how technology supports asynchronous and synchronous interactions among instructors and students.

Whether technology enhances learning is related to the character and function of technologies. In this book, power point, excel and iMovie are used as visual aids to present well-organized discipline knowledge in one way. In the other way, they are used to help learners filter information and construct knowledge through hand-on activities. The interactive features of synchronous conference, MSN, and GIS are used to connect learners immediately. The role-play and virtual learning environment are used to simulate the real-life context. All the authors specify their concern in the selection of the technology to fit in with their instruction design, infrastructure conditions, and learners' needs. The learning process is enriched when the instructors apply proper technologies in different functions to provoke learners' interaction and collaboration with others.

In addition to the selection of technologies, different integration models are required in diverse disciplines. In this book, several integration models are demonstrated in a variety of disciplines, which lead us to view integration models correlate with the discipline knowledge base. To elaborate rich context of psychology and counseling cases, CD-ROM and simulating environment are used in different levels to get learners immersed fully in educational situation. To present the abstract concept and spatial relations in earth science, GPS, Palm and digital tablets are used to help learners analyze qualitative and quantities data. Besides, to provide well-organized materials to the distributed or remote learners, email, forum, and teleconference are blended with classroom-based instruction. Due to the context-specific discipline knowledge and instructional situation, it is hard to get a fit-for-all model. Taking an example, Pamela L. Anderson-Mejias' "Online training for English as a second/foreign language teachers" and George Kafkoulis' "Project CineMath". In learning how to teach English, learners need more interaction and communication with peers than expert's answers. In contrast, learners need to self-discovery while learning the deductive ideas of math beyond instructor-led lecture. Technologies support asynchronous online course for learners to get instant feedback, and foster self-directed learning when they can review back and forth the reusable objects organized by subject and lecture. However, any model is based on firmly learning theory and special feature of disciplines, and there are some critical factors influencing integrating technology in higher education successfully. Those factors include instructional design, interaction, and infrastructure, which all center on learners' performance, cost efficiency, and teaching effectively.

As for the main concern, integrating technology in higher education is more than the presentation and delivery of teaching materials. The development and practice of leaning theory, where technology assists instructors to bring about more interaction and collaboration play a pivotal role. Instruction is a complicated system built in a real-life context while technology has been changing so fast that it is hard to provide any checklist to ensure the perfect model of teaching and learning. However, those cases in this book mirror the real situations among several universities and different countries. This book really contributes to the construction of technology integration model in terms of dimensions, strategies, and techniques, which can be adopted in other educational institutions. I would like to suggest the improvements on classification of the book in future editions. Appropriate articles could be categorized into 4 themes exactly. Then, it would help readers better understand which chapter they can grape at the first glance.

Graf, S. (2006). Book review: Adaptable and Adaptive Hypermedia Systems (Sherry Y. Chen and George D. Magoulas). *Educational Technology & Society*, 9 (1), 361-364.

Adaptable and Adaptive Hypermedia Systems

(Book Review)

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Introduction

This book contains more than an overview of different adaptable and adaptive hypermedia systems (AAHS). It provides a broad range of information about them and considers the incorporation of adaptation issues in hypermedia systems at different stages of the life cycle. Starting with requirements analysis of AAHS as the first section, architectural aspects, modelling techniques, application development, and evaluation methodologies are addressed in further sections. The book is organized in 16 chapters divided into the above mentioned sections. In a preface the editors provide an overview of the book and relate each chapter to the context of its section. Because all chapters are written by different authors, this preface gives a good introduction and helps to get the overall picture of each section as well as of the whole book.

Requirements Analysis

The first chapter presents two case studies dealing with incorporating adaptivity into digital libraries. In a first study, the requirement of providing adaptivity was identified by analysing the behaviour of novice users in digital libraries. The study shows that novice users have difficulties in framing queries and their behaviour during the searching process differs from the behaviour of experienced users. In a second study, an adaptive digital library is used. This library provides detailed non-adaptive information for beginners and gives adaptive tips regarding the result of a query. A tip includes an explanation about what happens during the search, showing the number of corresponding words found for each word in the query. Additionally, suggestions and examples for improving the query result are given. As a result of the second study it can be seen that novice users using the new features improve their seeking behaviour.

The second chapter aims at adaptive navigation support as answer to the problem of disorientation and “lost in hyperspace” in large websites. Attention is turned to the site structure, how it can be modelled and analysed as well as to aspects of modelling and analysing the navigation path of the users based on the site structure. Based on literature as well as on a performed study, navigation patterns predicting disorientation are discussed. Finally, different kinds of orientation glues are presented.

While the first chapter is practical oriented, showing that novice users of digital libraries can be supported by providing adaptivity, the second chapter discusses models, measures, and methods concerning site structure and user navigation in a more theoretical way, and therefore provides the basics for applying adaptive navigation support. When reading the title of the section, one would expect to read about studies which show that adaptivity and adaptability are useful and required concepts for different application areas of hypermedia systems. But the chapters show this only for two areas, digital libraries and the problem of getting lost in large websites. These two areas are good examples but do not cover all kinds of hypermedia systems. Incorporating adaptivity and/or adaptability can be used to enhance many different application areas of hypermedia systems. An additional chapter proving a summary of studies that shows the usefulness of adaptivity and adaptability in many different kinds of hypermedia systems would be very valuable for this book.

Architectural Aspects

Chapter three deals with adaptation engineering in adaptive concept-based systems. The authors provide an overview of engineering approaches and discuss the principles of adaptation engineering, including modelling the domain, user, and adaptation. Three main classes of adaptive concept-based systems are identified: adaptive web information systems, adaptive hypermedia systems, and adaptive task-based systems. Each of these classes is described and representative engineering methodologies and typical system architectures are illustrated by examples. Regarding adaptation, discussion is provided on how adaptation issues are incorporated in these three classes.

The Extended Abstract Categorization Map (E-ACM), presented in chapter four, is a conceptual tool for assessing and comparing methods and tools in adaptable and adaptive hypermedia systems concerning modelling mechanisms. Related to adaptation issues, four modelling perspectives are considered: services, traditional concerns, abstraction levels, and goal conditions. After a detailed description of E-ACM, a comparison of two adaptive authoring systems is illustrated using E-ACM.

In the next chapter a framework for facilitating the implementation of adaptive hypermedia systems is described. The framework follows a XML-based document-centric approach and supports adaptive presentation and adaptive navigation by providing document-oriented adaptation actions and model-update actions. As an application of the framework, the PALIO system is described. This system supports several kinds of adaptivity and has a special focus on accessibility issues.

This section provides a good overview of architectural aspects of AAHS. Different views are considered. While chapter three provides general information also beyond the scope of adaptive hypermedia systems (including web-information systems and task-based systems), the last chapter in this section is very specific, dealing with a XML-based document-centric framework for incorporating adaptivity. Because of the diversity of the chapters, the section includes valuable information for all who are planning to develop an adaptable or/and adaptive hypermedia system.

Modelling Techniques

The chapter “Learning Adaptive Behaviour” discusses briefly different kinds of adaptive behaviour. The core of the chapter gives an overview of machine learning approaches (Naive Bayesian Classifiers, Bayesian Learning, Artificial Neural Networks, and Relational Learning) used often in adaptive hypermedia systems. For each approach, a description including the basic underlying formulas is given, some applications in different domains of hypermedia systems are presented, and the advantages as well as the drawbacks are discussed. Finally, the approaches are compared and important questions for choosing a machine learning approach are mentioned. The chapter is very helpful for people who want to gather some ideas on which machine learning approach is suitable for a specific problem but should not be taken as only reference to decide about the applied approach. The author provides references to detailed descriptions of the approaches and its applications which should be read before deciding on one approach.

The next chapter offers a survey about web usage mining and points out the application of these techniques to adaptive systems. Cluster mining techniques are described in great detail, distinguishing between clustering web documents, references of web documents, and user visits. Furthermore, association rule mining techniques and sequential pattern mining techniques are presented. Each of these classes of mining techniques is described in a general manner and different approaches are presented pointing out their main characteristics. Regarding adaptation, discussion is provided about how each class of mining techniques can be used to support certain adaptation aspects.

The enumeration of approaches and their different characteristics are described in detail, presenting a lot of facts where the effects are not clear. Beside that, the chapter gives a good overview, explaining what web usage mining is and how it can be involved in adaptive systems.

Chapter eight is more concrete than the previous ones and deals with the problem of imperfect information in adaptive hypermedia systems. Especially for the user model and in consequence for the adaptation model it is important to consider information imperfection. The MAZE model, introduced in this chapter, is an abstract hypermedia model extended by built-in support for fuzzy set-theoretic notations to cope with imprecision. The extensions for incorporating fuzziness in the model are described in detail. To illustrate the MAZE model, a case study is presented, dealing with social relationships in group collaboration. Different aspects of imprecision handling and consequently adaptive behaviour are demonstrated. The chapter contains a lot of technical details but shows an interesting application of modelling in hypermedia systems.

The next chapter deals also with a concrete application of modelling techniques, namely word weighting algorithms in document-based adaptive hypermedia systems. The authors discuss word weighting algorithms and introduce an algorithm which incorporates the users' individual interests into the weighting process, distinguishing between consistent interest and spot interest. As an example, the algorithm is applied in a browsing support system, which highlights the most relevant and familiar words in a web page for each user. The system as well as the evaluation of the algorithm, comparing it to two other algorithms implemented in the system, is described. Although the chapter is partially formally written, describing algorithms, it provides a lot of concrete examples, figures, and tables, making it easy to understand.

This section shows modelling techniques for complex adaptive or intelligent systems. While the first two chapters provide an overview, the other two chapters deal with concrete applications. This combination makes the section very useful and helps to understand the different possibilities to make systems "intelligent". All chapters are written in a technical way, describing algorithms or techniques, which makes reading not as easy as in the other sections.

Applications Development

Chapter ten deals with adaptive virtual reality museums on the web and presents an architecture for supporting the development of such kinds of museums. After a discussion about the advantages and challenges of adaptive virtual reality museums, the proposed architecture is described in detail. The architecture focuses on adaptability and adaptivity, e.g. the interest of visitors in particular resources is determined, and the internet connection bandwidth can be declared by the visitor or be determined by the system. According to the user's profile including the determined and declared values, an individual virtual museum is generated.

The next chapter shows an application that combines the concept of virtual documents based on a semantic web approach with adaptivity. SCARCE – introduced in this chapter – is an adaptive hypermedia environment aimed at providing virtual documents adapted to the users' needs. The authors discuss the design principles and describe the components of the environment. It is illustrated very well how adaptivity is provided showing some examples.

The following chapter focuses on user modelling and personalisation aspects in knowledge management systems (KMS). After a discussion of trends and challenges in KMS and how to support user modelling with user ontologies, the advantages of user modelling in KMS are pointed out. One of these advantages is personalisation, which is discussed in more detail. The benefits of personalisation in KMS as well as the role of agents for providing personalisation are described. Finally, it is shown how structure, content, as well as presentation and modality can be adapted in KMS.

Chapter thirteen deals with adaptation issues in interactive television. The characteristics of interactive television are described and differences to web-based systems affecting adaptation are pointed out. Afterwards the authors discuss how adaptive hypermedia techniques used for web-based systems can be applied for intra-programme interactivity on TV, where the viewer can interact with broadcast content. For each adaptation technique, the arising problems are mentioned and possible solutions are provided.

The last chapter of this section is also about television but focuses on personalisation issues for advertisements. The main question discussed in this chapter is how to predict the rating of an advertisement spot for an individual viewer. The proposed approach combines the Pearson-based approach with data from the user's lifestyle. In an experiment, described in the chapter, the performance of several approaches is compared, varying the amount of already available user ratings for spots. As a result, a similarity-based approach on the basis of demographics and TV program preferences data lead to better performance than the typical Pearson-based approach for few available ratings and to statistically equivalent results for high availability of ratings.

In this section several examples of meaningful applications for incorporating adaptivity and adaptability in different kinds of environments are presented. The focuses of the chapters are quite different, reaching from describing hypermedia systems which consider personalisation aspects to more general issues showing how adaptivity and adaptability can be used in certain application domains, to more technical issues presenting approaches how personalisation can be implemented efficiently. This section involves adaptivity issues as well as adaptability aspects and delivers a broad overview of different areas where personalisation enhances environments.

Evaluation Methodologies

The first chapter in this section deals with common problems and pitfalls in the evaluation process of adaptive systems. The chapter makes the reader aware of possible problems and provides guidelines, recommendations or/and workarounds. Towards the end an overview of evaluation frameworks is given. The chapter is very helpful for planning and designing an evaluation. It gives a lot of ideas, makes the reader aware of possible problems and provides references for detailed information about the problems and their possible solutions.

The next chapter introduces the DMASC system, a tool for logging and visualising user paths through database-driven websites. The authors discuss logging methods and visualisation aspects, showing how DMASC realises the visualisation of individual user paths. To illustrate the benefits of DMASC, an application is shown, visualising 19.300 user sessions. Expected and unexpected user paths are demonstrated. The detection of unexpected user behaviour facilitated by DMASC system as well as the investigation of its reasons by the site designer allows to formulate adaptation rules which enhance the adaptivity of the website. An interesting aspect in this chapter is that the designers of websites are involved in the adaptation process. This idea can be applied also in other areas of adaptive systems in a more general way, e.g. in educational systems by involving the authors of courses in the adaptation process.

This section provides two interesting chapters, one dealing with evaluation methodology in general and the other showing a concrete example for evaluating the website structure. In the first chapter of this section, evaluation frameworks and some references are mentioned. However, an additional chapter about a concrete evaluation framework would be of merit. Chapter four, describing the Extended Abstract Categorization Map, covers this issue and therefore would also fit very well to this section.

Summary

In general, the book provides a very good overview of the state of the art in adaptive and adaptable hypermedia systems. As Brusilovsky mentioned in the foreword, "… until now there was no book that can capture a snapshot of modern adaptive hypermedia research in a way that the earlier book (Brusilovsky et al., 1998) captured the state of the art of classic adaptive hypermedia.". The authors did a really good job in providing this snapshot.

The book stands out by the diversity of its chapters. At the same time the sections are organised well so that there is no problem of losing the context. All together, the chapters show a great amount of current research work in different research areas and different application domains, all dealing with adaptation issues in hypermedia systems. This makes the book to a combination of theoretical and practical contributions, providing overviews and surveys as well as case studies and implementations. Because of this diversity, the book helps the reader to see new aspects and generate new ideas.

Regarding the title "Adaptable and Adaptive Hypermedia Systems", it should be said that the focus of this book is on adaptivity, adaptability is considered only in some chapters. However, this corresponds with the state of research, where more research work is done in adaptivity than in adaptability.

In conclusion, this book can be strongly recommended to everyone who is interested in adaptation issues in hypermedia systems, especially to people with a background in computing.

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