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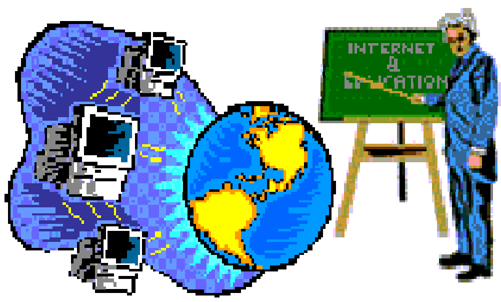

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Aims and Scope

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 The articles should be original, unpublished, and not in consideration for publication elsewhere at the time of submission to *Educational Technology & Society* and three months thereafter.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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Educational Technology & Society is abstracted/indexed in Social Science Citation Index, Current Contents/Social & Behavioral Sciences, ISI Alerting Services, Social Scisearch, ACM Guide to Compg Literature, Australian DEST Register of Refereed Journals, Computing Reviews, DBLP, Educational Administration Abstracts, Educational Research Abstracts, Educational Technology Abstracts, Elsevier Bibliographic Databases, ERIC, Inspec, Technical Education & Training Abstracts, and VOCED.

Sponsorship

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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)
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- Software reviews
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- Submissions should be single spaced.
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- There should be single space between full stop of previous sentence and first word of next sentence in a paragraph.
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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).

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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.

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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).

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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, 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, 2002 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**.

Journal of Educational Technology & Society

Volume 7 Number 4 2004

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Editorial

Dear Readers of the Educational Technology and Society journal,

With this volume, our journal completes its seventh year of publication. The first issue of ET&S was published back in October 1998.

During these years, a number of noticeable achievements have been accomplished. Let us summarize the most important of them:

- Sixteen (16) Special Issues have been published with topics such as: Ontologies and the Semantic Web for E-learning, Innovations in Learning Technology, On-line Collaborative Learning Environments and so on, mobilizing 20 Guest Editors.
- Eighty one (81) Regular Papers have been published covering all areas of interest in the field of Advanced Learning Technologies; it is worthy to mention that all received submissions undergo a double blind review process and the acceptance rate of ET&S has always been below 20%.
- The journal is now included in major scientific publication indexes, such as: ACM Guide to Computing Literature, Australian DEST Register of Refereed Journals, Computing Reviews, Current Contents/Social & Behavioral Sciences, DBLP, Educational Administration Abstracts, Educational Research Abstracts, Elsevier Bibliographic Databases, ERIC Clearinghouse on Information & Technology, Inspec, ISI Alerting Services, Social Science Citation Index, Social Scisearch, Technical Education & Training Abstracts, and VOCED.

In 2003, the Editors responded to your requests for hard-copy version of the journal. As from October 2003, the printed version of ET&S (ISSN 1176-3647) is published and circulated on a subscription basis.

Another major issue in 2004 is the complete re-design and upgrade of the journal’s web site. This work was undertaken by the Advanced e-Services for the Knowledge Society Research Unit of Informatics and Telematics Institute-Centre of Research and Technology Hellas in Greece. New functionalities have been added and the journal now has its own domain name at http://www.ifets.info.

Finally, we are pleased to welcome a new member in our Editors-in-Chief team.

As from September 2004, Prof. Demetrios G. Sampson, Head of Advanced e-Services for the Knowledge Society Research Unit of Informatics and Telematics Institute-Centre of Research and Technology Hellas and Assistant Professor in Department of Technology Education and Digital Systems-University of Piraeus has joined ET&S Editors-in-Chief team.

Dear colleagues, with this short editorial we would like to thank all authors of our research community who submitted their manuscripts for possible publication in our journal, all Executive Peer Reviewers who constantly support the peer review process in all these years and all of you who have made ET&S a major scientific vehicle in the field of Advanced Learning Technologies.

Yours sincerely,

Kinshuk
Demetrios G Sampson
Ashok Patel
Reinhard Oppermann

von Brevern, H. (2004). Cognitive and Logical Rationales for e-Learning Objects. *Educational Technology & Society*, 7 (4), 2-25.

Cognitive and Logical Rationales for e-Learning Objects

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Discussion Schedule:
Discussion: May 3-12, 2004
Summing-up: May 13-14, 2004

Pre-Discussion Paper

Motivation

The motivation for this discussion is to look at the cognitive and logical rationales of e-Learning objects, which reside in computer-based e-Learning artefacts. e-Learning objects, the system to which they belong, and the sequence of messages that form a discourse between the system and its environment are inseparable. Altogether, they formulate the "Universe of Discourse" (Wieringa, 2003, p. 14). When we talk about systems, we equally refer the discourse to e-Learning objects because they are the "workers" of the system. e-Learning is "a combination of content and instructional methods delivered by media elements such as words and graphics on a computer intended to build job-transferable knowledge and skills linked to individual learning goals or organizational performance" (Clark & Mayer, 2002, p. 311). The sciences of instruction, learning, and knowledge are intricate and the "e-" before "Learning" adds another dimension of complexity while paving new learning paths for e-Learning.

Keywords

e-Learning Objects, Cognitive Learning Theories, e-Learning Artefacts, Psychological Pedagogical Modelling, System Design, Subject Domain, e-Learning Object Theory, e-Learning Object Processes, e-Learning Object Methods, e-Learning Object Principles.

1. Introduction

e-Learning is a cross discipline artefact that spans e.g., philosophy, psychology, pedagogy, anthropology, artificial intelligence (e.g., Artificial Intelligence in Education (AIED)), and human computer interaction (HCI) (cf. Issroff & Scanalon, 2002). e-Learning artefacts should be more than just a technical solution; for example, a web-based e-Learning site (however sophisticated it may be) containing stylish multimedia assets, Java applets, and dynamic database bindings that engage users in multiple ways including prompting interaction at cognitive, behavioural, and physiological levels. e-Learning artefacts are probably compared most appropriately with information artefacts as known by the cognitive dimensions framework (cf. Green, 1996; Green & Petre, 1996) which describes the "system under investigation" as "something that has been built for the processing, storage and communication of information. Every information artefact provides one or more notations in which the information being manipulated is encoded … The environment used to manipulate the notation is equally important" (Blackwell, 2001; also, cf. Green & Benyon, 1996).

The user range interacting with e-Learning artefacts is large and multifaceted. Main actors are pedagogues, instructional designers, psychologists, and learners. Not only do actors have their individual expectations and assumptions towards an e-Learning artefact but also hold varying degrees of proficiency and professionalism (e.g., not every educator or psychologist is a professional pedagogue), motivation of learning (e.g., an adults student may have different techniques and motivations for learning than a student who has to memorise chemical formulas for an examination; an educator may not be elated to be taught by a computer system), education, environment, and alike. Ergo, anyone who engages in a learning process, using e-Learning artefacts becomes a participant in a versatile and complex learning paradigm.

When designing e-Learning artefacts, a non-expert may expect or assume a system's expert intelligence while an expert may wish to choose from available options or templates within the system, to adapt to, or even evolve further from behaviour (i.e., referring to knowledge representation, user behaviour, user action; cf. Dix et al., 1998). Similarly, a student may expect a virtual instructor to provide learning stimuli like an educator in the physical world. Accordingly, the attribution of action by learners prompts an immediate machine reaction (cf. Turkle, 1984). Indeed, if one were to design a schema to show all interactions and transactions of learning, then mapping these either a centralised e-Learning artefact or multiple e-Learning artefacts, it would be very easy to miss the cognitive and logical rationales used in tracing and exploring e-Learning objects and how these link to a higher e-Learning system. Although we are not exploring the technical aspects of e-Learning "system" interaction itself (cf. Muirhead & Juwah, 2004; Repenning et al., 1998), we are interested in the contextual causes by entities, actors, events, and requirements. Hence, expectations, assumptions, intended effects, underlying plans, situated actions (cf. Suchman, 1987), observable, and unobservable behaviour of ourselves and those of others must be known, distinguished, and formulated into explicit requirements to design e-Learning artefacts. However, depending on our epistemologies and research ontologies, observing processes is unnatural for us. Monitoring behavioural processes, initiated by cognitive (either conscious or unconscious) stimuli contain situated actions and reactions as shown in the following example: "… one shopper found an unusually high priced package of cheese in a bin. He suspected an error. To solve the problem, he searched through the bin for a package weighing the same amount and inferred from the discrepancy between the prices that one was in error. His comparison with other packages established which was the errant package. Had he not transferred the calculation to the environment, he would have had to divide weight into price, mentally, and compare the result with the price per pound printed on the label, a much more effortful and less reliable procedure" (Lave et al., 1984, p. 77). In Lave et al., 1984, the authors conclude on their example that the store setting and activities within the store "mutually create and change each other". Stimuli for such changes in our physical world are situations, or as Brown et al., 1989 argue: "Situations might be said to co-produce knowledge through activity. Learning and cognition, it is now possible to argue, are fundamentally situated".

e-Learning artefacts should not only deliver but also build job-transferable knowledge and skills in the learner so that e-Learning systems, in particular more than any others, ultimately accomplish human-like behaviour and reinforce us to interact with "the notion of a self-explanatory artefact … In this … sense the goal is that the artefact should not only be intelligible to the user as a tool, but that it should be intelligent – that is, able to understand the actions of the user, and to provide for the rationality of its own" (Suchman, 1987, p. 17). Consequently, e-Learning artefacts should be intelligent with clear-set learning goals i.e., "... the focus in thinking about distributed intelligence is not on intelligence as an abstract property or quantity residing in either minds, organizations or objects. In its primary sense here, intelligence is manifested in activity that connects means and ends through achievements" (Pea, 1993).

2. The Domain of e-Learning Artefacts

Bringing information and communication technologies (ICT's) into education has raised many issues, the least of which is how does the use of e-Learning artefacts improve or enhance both the learning process, motivation, help us build our knowledge base and increase our multiple intelligences (cf. Gardner, 1999). While studies of mutual intelligibility have been concerned with human action, we now have a technology available in e-Learning that has brought with it the idea rather than just using machines, we interact with them as well (cf. Suchman, 1987). Such interaction needs to investigate and separate the study of mutual intelligibility: The relation between observable behaviour and the processes not available to direct observation, that make behaviour meaningful (cf. Suchman, 1987). The expression "mutual" refers to and includes numerous actors and their disparate levels of interaction with e-Learning artefacts while processes of behaviour are essentially cognitive. The gain of interaction is the value of the perspective of one other and is a primary learning constituent in constructivist learning theories (cf. Jonassen, 1991), inducing mindfulness in learners (cf. Langer, 1990).

In view of most computer systems, however, we assume that a plan determines purposeful action (cf. Suchman, 1987) whereof "a plan is any hierarchical process in the organism that can control the order in which a sequence of operations to be performed" (Miller et al., 1960, p. 17). This rational notation also includes plans and goals, past actions, effects, their pre- and post-conditions, alternative and future actions.

The domain of generic systems, and how system thinking incorporates the use of e-Learning artefacts, has thus revealed the importance of psychological (i.e., cognitive) and social rationales which need to be firstly defined, then incorporated into any instructional design model that either uses or intends to use system thinking as a structure to build e-Learning artefacts. Cognitive, social, and even behavioural motives and intentions must be reflected in e-Learning systems more than in any other computer-based systems because learning is constantly evolving and changing, but also re-shaping how we interact on equally a psychological and pedagogical level. "An entity is a discrete identifiable part of the world" (Wieringa, 2003, p. 78) so that entities of e-Learning artefacts are primarily pedagogues and learners whose communication is subject to laws of psychology and pedagogy. Taken from here, we must precisely identify tasks and responsibilities of an e-Learning system and decompose them to analyse the functions, communication, and behaviour of e-Learning objects. Their authentic "... tasks and content analysis should focus less on identifying and prescribing a single, best sequence for learning and more on selecting tasks that are both meaningful and able to accommodate constructivistic applications" (Jonassen, 1991, pp. 29-30). However, it is important not to exclude cognitive and behavioural schools of thought and how they impact the design of and use of instructional technologies. There is no central answer as to how effectively to build or construct e-Learning artefacts, nonetheless, information can be dynamically inferred from its environment (cf. Suchman, 1987). The key to such information is the subject domain (as discussed in the subsequent section). Notably, such context-driven, evaluative information is meaningful although "… real-world criteria may be very objective. But they are real-world, and to the extent that they reflect real-world criteria, they are meaningful" (Jonassen, 1991, p. 30). Indeed, defining the "meaning" of what an e-Learning artefact is, to then apply its pedagogical context (e.g., cognitive; behavioural or social) is key to understanding and planning educational technology systems that are interrelated to "subject heavy domains" or "context specific" environments.

3. The Subject Domain

The subject domain (also known as the Universe of Discourse as described by Wieringa, 2003) helps us to capture contextual actors, messages, responsibilities, and alike: "So the subject domain of the system is the part of the world that the messages received and sent by the system are about. To find out what the subject domain of a system is, ask what entities and events the messages sent and received by the system are about … to count as elements of the subject domain, these entities and events must be identifiable by the system" (Wieringa, 2003, p. 16). Wieringa, 2003 further specifies, that "The subject domain of a system not only consists of nature and previously installed systems … but also of people and their socially defined reality, including norms and meaning conventions" (Wieringa, 2000, p. 2). The collection of all possible symbolic interactions is called functionality and consists of three classes i.e., the information function, the control function, and the declarative function (cf. Wieringa, 2000). Its objects and components achieve functionality of a system. Therefore, when we refer to a system in the following discussion, we must bear in mind that it is the responsibility of its objects and components to realise the functionality.

We can now induce that the subject domain of intelligent e-Learning artefacts talks about delivering and constructing pedagogically and psychologically valid learning contents to learners. Therefore, messages (e.g., pedagogical, psychological, and alike) must be learner-centred (cf. Moreno & Mayer, 2000; Smulders, 2003; Coman, 2002) and not instructor-centred while learner-centeredness also includes autonomy and control (cf. Saba & Shearer, 1994). On the contrary, if we assumed that an intelligent e-Learning system should help and instruct educators to design pedagogically and psychologically valid e-Learning contents, the subject domain then talks about the construction of contents. In this case, messages are still learner-centred because the educator becomes a type of learner. Also, if both foci fell into place learning activities would truly be blended (cf. Orey, 2003). In either case, however, the subject domain of a system always talks about identifiable methods and events to construct, build, and deliver learning contents to learners but not about the actual learning contents itself. The exclusion of contents supports Moore, 1989's argument of the three types of interaction (i.e., Learner-Content Interaction, Learner-Instructor Interaction, Learner-Learner Interaction) because the subject domain talks about how learners acquire intellectual facts and not about the contents of the intellectual facts.

The nature of a learner-centred interaction is something much greater than a simple transmission of information, navigating through learning contents (cf. Smulders, 2003), or "a mere process of passive reception and acquisition of knowledge" (Nunes & McPherson, 2003, p. 497; Giebler, 2000). We would therefore expect these types of events and messages of the subject domain to be of pedagogical nature to facilitate learning. Nevertheless, pedagogy is rather heuristic i.e., an objective experience of how to teach, and is henceforth primarily derived from situated actions. Pedagogy is argued to be ill-structured as Allert et al., 2002 argue, neglects research of theories in educational technology (cf. Issroff & Scanalon, 2002), and is thus not suitable for computer-based artefacts which are built on planned actions and intents contrary to situated experience. Situated actions in pedagogy become problematic when it comes to designing e-Learning artefacts so that this, in turn, exactly becomes one of our greatest challenges. According to Suchman, 1987, one of the propositions of the ethnomethodological view of purposeful action and shared understanding claims that plans are representations of situated actions. Rather than direct situated action, rationality anticipates action before the fact, and reconstructs it afterwards (cf. Suchman, 1987, p. 53; Mead, 1934). However, as of today, no such e-Learning architectures exist, which holistically de-construct this evolving paradigm. One attempt has been made by Reeves, 1996 who raises the issue of the forth paradigm which follows the Analytic-Empirical-Positivist-Quantitative paradigm, the Constructivist-Hermeneutic-Interpretivist-Qualitative paradigm, and the Critical Theory-Neomarxist-Postmodern-Praxis paradigm: That of an "Eclectic-Mixed Methods-Pragmatic Paradigm" (cf. McLoughlin, 1999; McLoughlin & Oliver, 2000; Phillips et al., 2000) which is specifically designed to solve educational technology problems. However, the literature on this forth paradigm is limited and there is great need of research on its theoretical and practical merits.

Contrary to the pedagogical predicament, theories originating from psychology (e.g., instructional processing theory, instructional-design theory; cf. Reigeluth, 1999) tell us how knowledge is represented, built, processed and alike in memory. Gagné et al., 1992 argue that instruction is "A deliberately arranged set of external events designed to support the learning process" (Gagné et al., 1992, p. 11). Instructional events are "… external, when deliberately planned and arranged constitute instruction" (Gagné, 1985, p. iv). Although there exists a myriad of psychological learning theories, models, and principles from cognitive and constructivist psychology, precise methodologies are needed specifically for e-Learning which allow objects of a system to execute identifiable events and messages. Moreover, such events and messages must be based on non-contradicting approaches as for example, an instructive versus a constructivist approach. Beyond, with a complex system in mind where for instance the artefact instructs an educator to construct a course and also delivers learning contents to a learner, learning processes cannot be fixed. Hence, our challenge as designers is to find both an optimal learning and teaching process, and identify how to support the interaction between them. To assume that a singular learning process will suffice may be a grave error in design.

Entities of the subject domain are reliant on the type of e-Learning system. We will find a broad modality (a term described by brandonhall.com, 2003) spectrum such as mobile learning, web-based learning, distance learning, and more. Geographical distance is less important than the interaction between the learner and the educator (cf. Moore, 1973; Moore, 1989; Coppola & Myre, 2002). As discussed earlier, the system could be the educator itself, which supports our argument that e-Learning artefacts must be intelligent as well as pedagogically and psychologically valid, more than most other systems. Presently, the most popular e-Learning systems deliver online packaged or instructor-led (i.e., system-led or man-led) courses and tutorials so that we infer that packaged courses or tutorials led by the system have more responsibilities than instructor-led ones. In either case, the subject domain talks about the nature and norms of an entire course structure, which is the composition of its individual components (e.g., module, lesson, assignment). The actual learning content that is outside the responsibility of the subject domain is the substance of the individual components. The term component used here is not to be confused with Merrill's Component Display Theory (CDT) (cf. Merrill, 1983; Clark, 1999) although it is interesting to note how the CISCO, 2003 course structure applies Merrill's components. Even though the subject domain talks about how to construct a course, no rational, pedagogical models exist that would tell us how course structures, lectures, or components are to be built validly. The term "lecture" hereto implies cognitive and constructivist learning processes and differentiates from a conventional, instructivist lecture as known from the physical world. At a lower level, we will find principles of instructional design (cf. Gagné et al., 1992) and cognitive learning principles (e.g., modality principle, contiguity principle; cf. Clark & Mayer, 2002; Clark & Harrelson, 2002; Moreno & Mayer, 2000). Despite their cognitive values instructing us of how to reduce the burden of working memory, these principles however, are nearly impossible for a system to put into practice. For example, these principles teach us that presenting visuals emphasising relevant and critical details is effective while arbitrarily adding visuals does not increase learning at all. Henceforth, a system will not be able to elaborate when a picture will be too many as also related to the cognitive load theory (cf. Sweller, 1988; Miller, 1956). Again, it is the educator or the instructional designer who holds responsible for the contents. Alternatively, what if the system were to help or instruct the educator or instructional designer? The issue is relevant because often, educators believe that fine-looking pictures make a lesson look attractive or give a relaxing ambience and do not know that learning is better when extraneous, content irrelevant materials are excluded (contiguity principle).

At last, the subject domain must therefore talk about logical operability within course structures, the binding between contents based on logical acquaintances and aggregations. These include knowledge mining, functional operability and computational algorithms, and many more to enable the system's functionality.

4. Retrospection and Reinvigoration of e-Learning Systems and their Objects

Commonly known definitions of e-Learning objects clearly lack the significance of our previous discussion based on the norms and contextual nature of the systems in which e-Learning objects reside. Known definitions do not take intelligence and pedagogical and psychological validity into account, miss the responsibilities they have to fulfil, and disregard the complex interactions they must accomplish. For example, learning or e-Learning objects today are constructed from an instructivist view point (e.g., the Lego metaphor and its debate; cf. brandonhall.com, 2003; Littlejohn, 2003; Rehak & Mason, 2003), mix the physical learning with the digital "e-" learning world (cf. LTSC, 2002), are unclear about granularity (cf. Wiley, 2002), lifespan (cf. L'Allier, 1997), and nature (e.g., database entities; cf. Merrill, 1998).

However, the stringent requirements imposed by the subject domain can best be accomplished by an object-oriented (OO) approach. An OO paradigm offers better support for reuse, is qualified to incorporate instructional operations, and outweighs the capabilities of static database entities. Objects as known by the OO paradigm can be assigned responsibilities, change internal states, communicate by exchanging messages, react to external stimuli, cause effects, and respond to internal causes.

5. Conclusion

e-Learning artefacts, their objects, and the discourse they create in their environment express an e-Learning based Universe (of Discourse). While the domain of learning is already complex, the technological edge in e-Learning increases its intricacy. Yet, technology presents new dimensions in learning. e-Learning includes various disciplines which call for the need of an intensified communication and research when it comes to devising e-Learning artefacts. Their range of uses is versatile; individuals hold different expectations and assumptions towards systems, portraying various degrees of proficiency and professionalism including learning motivation, levels of education, and more. Human processes and interactions are intertwined and rely on underlying plans, situated actions, observable and unobservable behaviour. Humans learn and co-produce knowledge by these some of these processes and interactions. Similarly, e-Learning artefacts, which (in some cases are designed to build job-transferable knowledge and skills) are linked higher learning goals, which should be intelligent because they should be designed to understand human processes and interactions.

Traditionally, the learning domain has been a highly complicated, full of meaningful processes and interactions between an educator and a learner. With e-Learning artefacts, as researchers in the field we now not only find another intelligent actor in the picture, adding new degrees of interaction but also uncover a need to introduce new levels of processes and behaviour into systems that are essential to cognitive awareness, inducing mindfulness in learners. e-Learning artefacts are primarily built on planned action and are subject to the nature, norms, and laws of pedagogy and psychology. From this environment we can dynamically infer tasks and responsibilities for e-Learning artefacts. To comprehend the notion of the subject domain and identify (the part of the world that is relevant to a situational e-Learning artefact) we have chosen the metaphor that the system simply exchanges messages with its environment. This functional decomposition must result in identifiable entities, messages, and events to the system.

Pedagogical and psychological construction and delivery of contents rather than the actual content are major key issues. Thereupon, intelligent e-Learning artefacts must be entirely learner- rather than instructor-centred to the one, and prove pedagogical and psychological validity to the other.

Learner-centred interaction in e-Learning is about actively building knowledge in a learner's memory. This is a shift of paradigm from the conventional way of instruction. Conventionally, learners were assumed to be passive vessels ready to be filled with knowledge; however, this due to the introduction of educational technologies into learning environments, learners are not longer passive, and educators now have vessels (like instructional technologies) from which to communicate and share content with their students. Messages and events of the subject domain of an e-Learning artefact as well as in the context of related subject domains are therefore concerned with the delivery of content and active knowledge construction. The interactive and constructive process which deliver learning content embraces a multitude of facets and possible scenarios e.g., the roles, types, and levels of interactions between the system, the instructor, and the learner. Intuitively, we would assume that such delivery processes should primarily be of pedagogical nature but because pedagogy is mainly based on situated experience, it is not always suitable for e-Learning systems. On the contrary, psychological learning theories, models, and principles seem to give way to deliver learning content but they are still not sufficiently refined yet to be identified by a system. Also, these theories, models, and principles must all cohere within an artefact. Likewise, learning processes cannot be fixed and we are challenged to find optimal learning and teaching processes and to know the interaction between them. To assume that a singular learning process would suffice may be a huge error in design. Another particular area of messages and events of the subject domain relates to e.g., logical operability within course structures, knowledge mining, curricula, and computational algorithms.

De facto, presently known definitions of learning objects for e-Learning artefacts have not taken the diverse cognitive and logical rationales into account, which primarily come from the domain of learning (based on pedagogy and psychology). In more detail, the working with subject domains has helped us decompose entities, events, messages, laws, nature, norms, and alike leading to an OO approach which would be most suitable to satisfy these stringent requirements. Although the "e" before learning has brought forth new complexities of interaction, mutual intelligibility, situated action, planned action, pedagogical and psychological validity the "e" is maybe also about to bring forth a new shift of paradigm to conventional learning. We are challenged to re-evaluate how humans perceive computer-based e-Learning artefacts, design learner-centred e-Learning systems and their objects while being involved in e-Learning. As e-Learning stretches across many subject areas, there is a need to resolve semantic spaces between pedagogical and psychological learning theories, models, and principles to make them identifiable for computer-based systems, whilst constructing teaching models where the educator, the system, and the learner evolve together.

6. Questions for Discussion

6.1. Interdisciplinary issues to e-Learning artefacts:

a) Where are the intersections between different disciplines when it comes to system development of e-Learning artefacts?
b) What are the (functional and non-functional) commonalities of requirements for system development by the disciplines?

6.2. If a computer-based artefact must be intelligent and psychologically valid, then an e-Learning artefact and its objects must also hold true pedagogical validity:

a) Is pedagogical and psychological validity inseparable (cf. IMS Global Learning Consortium, 2004)?
b) What are the pedagogical and psychological requirements for an artefact to be pedagogically and psychologically valid?
c) What are the concise pedagogical and psychological learning theories, models, or principles to accomplish pedagogical and psychological validity for an e-Learning artefact? (Including semantic spaces between learning theories, models, and principles)

6.3. Degrees of pedagogical and psychological validity of e-Learning artefacts and their objects:

a) Which pedagogical and psychological validity is the artefact to accomplish in view of levels of interaction, authority, trust, and responsibility?

6.4. Meaningfulness of plan, action, and intent to build a packaged e-Learning course system:

a) Should pedagogical requirements for an artefact be expressed in terms of purposeful actions and plans, heuristics (situated actions) or both?
b) What models and theories formulate a structured approach considering situated actions?

6.5. The subject domain of packaged e-Learning course systems and inferred types of e-Learning objects:

a) What should be the responsibilities of a system delivering packaged e-Learning courses referring to our discussion regarding user and system roles, issues of interaction, relevance of contents, and alike? For example, conventional courses are different from the idea of concept maps (cf. Passmore, 1998; Novak &

Gowin, 1984; Novak, N/A; Cañas et al., N/A; Institute for Human and Machine Recognition, N/A; Mintzes et al., 1998) and so may be their fields of application.

b) What types of e-Learning objects, messages, events, and responsibilities can be inferred from the subject domain? For example, *Learning Community Objects* (cf. Van Assche, 2004).

c) What pedagogical and psychological learning theories, models, and principles exist to construct a full e-Learning lecture or course considering the threefold aspects of theories, models, and principles? For example, “Theories that emphasize the situated properties of human action and learning have been very influential on current understandings of these phenomena. Work on situated actions by Suchman, 1987 on situated learning and cognitive apprenticeship by (Lave & Wenger, 1991; Collins et al., 1991; Wenger, 1998; cf. Ghefaili, 2003) and have been extensively used in analyses of learning and interaction” (Tholander & Karlgren, 2002, p. 1).

7. Post-discussion Summary

Formal discussions were held in both the International Forum of Educational Technology & Society (IFETS), during May/June 2004 and the Instructional Technology Forum, in July 2004. The following post-discussion summary treats each forum separately.

In the following summaries, the author excludes his own comments which are archived and available electronically.

7.1 Post-discussion Summary held at the International Forum of Educational Technology & Society

The first question looks at interdisciplinary issues involved in developing e-Learning artefacts in view of commonalities of requirements with reference to user profiles, and systems thinking.

Taken from her experience, **Beatrice Traub-Werner** has observed that one tends to assume that those learners participating in a program share commonalities, the same cultural perceptions, the same kind of educational profiles, and alike. However, when it comes to recognizing user profiles, challenges arise, the assumption of prior knowledge, and the variety of socio-ethno-cultural backgrounds. These factors and others, become important contributing influences occurring at the predevelopment stage of e-Learning artefacts. Beatrice Traub-Werner has concluded that that no ‘uniformity’ of user profiles exists since individual instructors are clear about the intended delivery and outcomes.

Frances Bell believes that the situated aspects of learning could be explored better if we regarded learning as taking place within a human activity system. In this respect, Frances Bell believes that, rather than focusing on ‘hard system’ thinking, Peter Checkland’s soft systems methodology (SSM) is appropriate in developing e-Learning artefacts (cf. Checkland, 1988; Checkland & Holwell, 1998; Checkland, 1999).

The second question has tried to explore the meanings and extent of psychological and pedagogical validity in e-Learning systems. The discussion, however, has continued on requirements analysis and elicitation by including differences between categories of e-Learning artefacts and the LO (Learning Object[s])/SCO (Shareable Content Objects) paradigm. While these discussion threads have addressed equally the third and fifth questions they have clearly revealed the complex and entwined degrees of e-Learning.

Hao-Chuan Wang has drawn our attention to the differences between the concepts of ITS (Intelligent Tutoring Systems) and LMS (Learning Management Systems) which are due to the practitioners and problem domain of the respective systems. However, he believes in the convergence of both (cf. Brusilovsky, 2003). ITS and AHS (Adaptive Hypermedia Systems) as addressed by Brusilovsky, 2001, Brusilovsky, 1996, and de Bra et al., 1999 typically focus on user modelling liasing to user interaction on the basis of HCI (Human-Computer Interaction) while LMS are based on the paradigm of LO and management concerns (cf. Wang & Li, 2004). However, LMS and AHS/ITS are not mutually exclusive ideas. Each attempts to address different facets of the incorporation of computers into education. If we want to compare their differences, we should then look at their backgrounds and functionalities. Both, management and interaction are parts of the requirements e-Learning artefacts need to provide. This encompasses the delivery of pedagogy, instruction, tutoring, and learning and therefore, both types of systems have their own validity of existence. This perspective excludes the question of superiority or inferiority of either system while, however, we may consider merging both systems.

Nevertheless, the notion of LO/SCO causes obstacles when it comes to interpreting ITS or identifying the corresponding parts of ITS equivalent to LO. Doing so partially addresses the subject matter of the type of e-Learning paradigm existing in ITS. Many ITS systems for example, ANDES (cf. VanLehn, 2002), which tutors students interactively to solve homework problems of Newtonian Physics, facilitate learner problem solving. The system uses Bayesian networks (cf. Stern & Woolf, 2000; Horvitz et al., 1998; Stern et al., 1999) to organise pieces of domain knowledge and steps of problem solving i.e., a fine-grained domain model. Furthermore, it makes use of probabilistic reasoning to identify students' buggy actions and attempt to direct students towards the right solution of a particular physics problem. The domain model consists of nodes and steps which, if we relate these to the LO paradigm, will let us wonder which ones should be an LO. In consequence, we may query about the level of granularity leading us to conclude that an individual physics problem within ANDES itself may be regarded as an LO. Yet, the consequence of such inference will agitate the types of methods of how to mark-up metadata of this type of LO and of how to resolve the dynamic nature of interaction at run time because learning activities and experiences are dynamic and not easily to be packaged and reused as conventional static materials. The consequence of inferring the individual parts to an ANDES physics problem are LO confuses the issue of metadata mark-up. This confusion could weaken the functionality of each LO when student-learning requirements trigger a required response. LO/SCO, by their nature ,are illiterate and static. This static nature makes their use in ITS difficult because these systems are designed for specific domains and purposes.

Another example taken up by Hao-Chuan Wang refers to STEVE (cf. Rickel & Johnson, 1998) which is an ITS with pedagogical humanoids in a virtual reality environment (in memorial of Prof. Rickel, N/A).

Both examples detect various flavours of the ITS field.

Hao-Chuan Wang further discusses pedagogical and psychological validity based on the LO/SCO paradigm by which he argues another impediment of this very paradigm. In the same manner computer algorithms, which are usually described in pseudo-code rather than actual programming syntax, the validity of which is judged by both its implementation and through mathematical analysis. Hao-Chuan Wang argues that it would not be reasonable to validate the pedagogical and psychological content if it were packaged in LO or used in systems that were built on the notion of LO. He believes that the quality of learning material could have two meanings:
1) learning material residing in LO, and
2) educational evaluation criteria such as achievements, and attitudes.

In this respect, tracing the chain of development of instructional design methods is directly related to the quality of the learning content. In addition, it is also suggested that we ought to consider implementing these methods in computer systems.

In the context of this discourse, Hao-Chuan Wang reminds us of the debate on the effectiveness of different media on learning (cf. Materi, 2001). While Clark, 1994 claimed that 'media will never influence learning', Kozma, 1991 has indicated that 'media and method are inseparable'. He therefore places emphasises on the importance of experimental evaluation allowing us to prove pedagogical and psychological validity by deploying standard scientific methods. ITS are real and not a dream of Artificial Intelligence (AI) for they have significantly shown effects to improve learners' achievements based on adequate experimental proofs (cf. Koedinger et al., 1997).

In his discussion, Hao-Chuan Wang has intentionally used the term 'computers in education' instead of e-Learning. To him, the main objectives of what the subject domain of today's e-Learning tries to attempt is inconclusive and thus unclear. Should it be better learning achievement, economical benefits, or both? The role of computers in education is therefore less ambiguous. Computers can be used as active tutors, as simple simulation, a tool for collaboration, or discussion tools as an active part of classroom-based learning activities. The objective is plain and straightforward i.e., to achieve successful learning as discussed by Lajoie & Derry, 1993. In his eyes, this very ambiguity about the objectives of e-Learning itself is becoming more and more an issue in related fields like LO, ITS, AEH (Adaptive Educational Hypermedia), Educational Technology, Educational Media, and more. In Conclusion, Hao-Chuan Wang thinks educational professionals and non-professionals seem to regard the elements of e-Learning as found in ITS and AHS to be mere learning extensions of SCORM as described by The Learning Systems Architecture Lab (LSAL), 2003.

Other Resources provided by Hao-Chuan Wang: Eklund & De Bra, 1995; TU/e, N/A; elm, 2003.

Mitchell Weisburgh believes that LMS serve as information containers, record user navigation, monitor courses taken, and skills acquired. In contrast ITS are believed to be more integral with courses and are more capable of deeper analysis for better skill adaptation while having the ability to offer alternatives. Mitchell Weisburgh has developed a system that stores courses, tracks individuals, diagnoses skills, and prescribes actions and remediation (cf. CollegePilot, 2004). He also addresses the influence of system design onto the outcome of the course itself which is ultimately perceived by users (cf. Weisburgh, 2003).

Mitchell Weisburgh does not think it is possible to come up with a generalised way to use an LO to build a course then have that course flexible enough to meet the needs of a large body of students. The course author expends much effort becoming familiar with LO and not much in metadata development is found fitting the course. Yet, he would use existing LO to supplement future primary material he may develop. Building a course out of existing LO is not practical for him.

Jean-Marc Dubois has emphasised that education is a particular way of communication and that communication is more important in learning than information. Therefore, when it comes to LO, Jean-Marc Dubois has stated that LO need recipes, i.e. a description of their composition. He has related this description to the use of metadata. Metadata is required to talk of LO and LO repositories while, in his opinion, (a set of) asset(s) without metadata should not be called LO but should at best be regarded as a piece of information. LO, therefore, can only be considered as objects if there is data describing them and more particularly if there were pedagogical information concerning their usage. He believes that ‘the smaller the object, the bigger the metadata’ while two dependent granular assets will need to be described by their metadata.

ITS, a kind of Computer Based training tools, are able to react to the learners on the interface. Any entity doing training, even with classical face-to-face sessions, can use LMS, which is regarded as a learning tool helping us manage training. In addition, the idea of putting ITS capabilities into LMS is a way of introducing rules that are more complex. Jean-Marc Dubois thinks most of the trouble is that some presume that e-Learning has effects on learning while as of yet there is no conclusive evidence.

In **Michael Verhaart**’s perspective, LO have different degrees of granularity and consist of
- A metadata file containing a description of the object itself,
- A set of files making up the course content –with pedagogy, and
- A set of resources, which you term the database entities or assets.

Engin Koc argues that learning and teaching (pedagogy) cannot be separated and raises issues in relation to flexibility and routes of communication. In his view, a major obstacle relates to LO residing in LMS.

The third question relating to the degrees of pedagogical and psychological validity has expanded the discussion by a debate on pedagogical, psychological, philosophical, instructional, and educational aspects. These discussions have paved the way for the fourth and fifth questions.

When it comes to emotional factors in learning, **Alfred Bork** believes that learners should always enjoy learning (cf. Bork & Gunnarsdottir, 2001). Stimuli that Alfred Bork indicated were:
- Everyone should succeed.
- The language of instruction should be always friendly.
- Exams should be invisible to the student.
- Learning should be an active process.
- Learning should be individualised.
- Learning should take place in groups.
- Knowledge should be discovered.

In response, **Michael Butler** believes that a hierarchically based learning content within a system should be time constrained to attain mastery.

David Piper feels there are many facets to learning and to personal perception within a particular context. He has argued that some people might view learning as a memorisation process, others view learning as a practical applicability of things remembered, others believe learning should be measurable, while the neurological perspective considers learning as a connection of and creation of neural pathways. Another observation considers motivational backgrounds towards learning linking to varying social backgrounds, for example, finding better jobs or making better contributions to society. Moreover, motivational stimuli in the brain might relate to the need of survival, which humans may not necessarily perceive consciously. In agreement with Jensen, 2000 and other cognitive scientists, David Piper believes that the primary function of the brain is survival. Both views towards learning outlined earlier i.e., training for professions in the world of ‘abstract’ and skills for the ‘concrete’ share the fundamental concept of providing a means for employment, which in turn, provides a source of income to survive. We could therefore make the assertion that the brain only ‘learns’ what is needed to ensure survival. However, there are two counter effects to the previous assumption:

- If we accept remembering as a type of learning the brain will remember things that we do not always recognise. The reticulate activating system (RAS) filters information and only calls the brain’s ‘attention’ to those environmental factors that can threaten our survival. The brain remembers everything but also acts on perceived threats to survival.
- Empirical evidence shows multiple examples that contradict the assumption. For example, there are people who thrive on trivia and play games where trivia knowledge is keen. As a second example, David Piper has provided an example by reminding us of how easily we memorise advertising slogans that – in most cases - have no relevance to survival, at all.

David Piper, therefore, claims that we should not consider learning processes in isolation. A successful i.e., valid and predictable learning theory needs to be developed that considers motivational facets, the neural processes in a human’s brain, individual learning styles, didactic teaching styles, and environmental contexts.

In David Piper’s eyes, a learning theory has a number of responsibilities:

- To convince the learner’s brain that what is being offered as the ‘knowledge domain’ would be worth knowing. This could be accomplished by convincing the brain that the domain would have impact on the learner’s survival. In addition, such conviction would make the brain more teachable;
- To convince the learner’s brain that what is being offered as the ‘knowledge domain’ would be worth knowing. This could be accomplished by convincing the brain that the domain would have impact on the learner’s survival. In addition, such conviction would make the brain more teachable;
- To take advantage of both short-term and long-term memory;
- To consider learner’s learning styles;
- To take into account the teaching style in a formal setting; and
- To take into account the construction of the learning context and environment.

David Piper also believes that philosophy, psychology and education cannot be totally separated. The crux of e-Learning is in discussing, choosing, and justifying the underlying theories and processes used.

Alex Heinze has taken our view to epistemological and ontological perspectives. Alex Heinze does not feel at ease with the view of the soft science background claiming there would be no right answer available. While relating to Laurillard, 2002 where the author claims that constructivism and instructional design are limited to application, Alex Heinze has addressed difficulties such as different learning styles, different lecturing styles, motivations, and alike. Alex Heinze believes that we should consider the conversational model whose main feature is the flexibility of dialogue. More specifically, with reference to Laurillard, 2002, Chapter 4 on ‘Generating a teaching strategy’, Alex Heinze points out an argument that Instructional Design Theory is logically based, not empirically based, therefore unable to build teaching on a knowledge of students and concludes that phenomenography is the more fitting approach.

Ania Lian argues that theories are to be explored in relation to how they enable us to achieve our goals. According to her, everything about learning is abstract so constructing systems according to some learning theory should not be undertaken.

No direct responses have made concerning the fourth question while discussions have explored further on the LO paradigm and built a broad spectrum of facets with regard to pedagogy, pedagogical ad psychological learning theories, models, processes, and principles as addressed by the fifth question.

On the basis of the work by Reigeluth & Frick, 1999, **Goknur Kaplan Akilli** contends that the choice of a learning theory is determined by preferences such as effectiveness, efficiency, and appeal. Coupled with these aspects, he added aspects on usability of a system. According to him, these facets must be added whenever it would come to evaluating learning theories (cf. Nielsen, 1994).

Michael Weisburgh has argued that without a learning theory, we will never get the metadata about LO right; nor would we get online ‘courses’ right. In his argument, he has suggested that we might look at the layered theories of knowledge and skills.

David Piper believes that Instructional Design models (ID) are static but due to a number of factors, we will need a fluid model much like a Lego metaphor.

Based on his exhaustive academic experience in science, **Alfred Bork** has argued that 'the hallmark of a successful theory is its predictive value' while predictability itself must prove validity. He has related learning and his experience to 'quantum relationships with consciousness and the human brain'. Alfred Bork has therefore drawn our attention to the issue of what a successful learning theory ought to predict.

Lorraine Fisher has argued that the discussion on learning theories, models, processes, and principles needs to include the domain of philosophy. More specifically, she relates her argument concerning the philosophical basis of choosing technology in curriculum to the development of an Instructional Design (ID) model. Once this choice is made, Lorraine describes an ordered procedure; choice of an appropriate theory, designing a model, applying the model.When this process is complete, principles and practices will emerge.

One obstacle to starting with the philosophical base, according to her, is concern with time constraints or resources to 'contemplate epistemological underpinnings of an approach'.

In conclusion, Lorraine Fisher has extended predictability of a successful theory with the need to assign a metric or measurement to theories.

According to Richard Dillman, the goals of e-Learning artefacts should focus on intelligent learner interaction. Therefore, e-Learning artefacts should be able to understand the action of the user, and provide for the rationality of its own. For Richard Dillman who is working between scientists and engineers over the creation of intelligent computer programs, the potential development, control, and explanation of AI is more pragmatic and appreciated.

He also argues that a theory could be seen as an 'expression of an attempt to understand' which gives rise to human curiosity trying to reason how 'an individual mind changes during a particular exercise'. Nevertheless, according to him, we are unable to describe the state of any one particular brain so no complete learning theory can yet emerge. Therefore, Richard Dillman deduces that the discussion should not focus on learning theories but should be related to two engineering assumptions:
1) Treating a large number of individuals in the same manner as one individual is treated,
2) The possibility to design simulated learning environments, which would substitute for teachers.

One of the issues regarding such environments, however, needs to look at the possible discrepancy between knowledge acquired by (a) learner(s) versus the intended knowledge taught by the teaching body. Although the issue of controlled learning is not new, Richard Dillman has posited that simulated learning environments will need to focus on the efficiency of teaching merged with the learning media i.e., the materials alone should suffice to teach.

Richard Dillman thereof addresses two areas of interest, the cultural aspect (delivery by electronic media) and the commercial aspect (dissemination of information on a CD is inexpensive).

Although Richard Dillman has programmed instructional modules for over 30 years, the only benefit, Richard Dilman addresses, is the convenience of presenting and teaching information electronically. He therefore concludes that simulated learning environments should help spend less time on simple, repetitive tasks so that he could spend more time encouraging students to think and communicate critically (cf. Dillmann, N/A-a; Dillmann, N/A-b).

With reference to 'The Society of Mind' by Minsky, 1988, **Ania Lian** believes that learning can be seen relationally which means that it is an 'on-going' process. She emphasises that one constructs relationships in order to have a greater sense of control. Therefore, in her eyes, a learning theory is not much more than a semiotic model.

On the issue of 'Do e-Learning platforms truly dictate the pedagogy?', Ania Lian has used WebCT since 1995 and never has it happened that a platform has dictated anything to her. She believes that making the platforms capable of being used intelligently instead of needing a learning theory and interacting with fellow educators (for example, sociologists, semioticians, and more) is what it means for the platforms to adjust to intelligent uses. On this basis all the functions of learning theories and descriptions of types of knowledge can be subsumed in platforms which do not seek to teach but are flexible to facilitate intelligent manipulation of information. It is suggested that we should start at one of the easier levels and develop a good theory and methodology for teaching at that level and then expand from there.

Ania Lian also believes that the need for learning theories should not be based on human curiosity but on intentional education to transmit knowledge. Teaching one as teaching many would be questionable. The complex issues involved in e-Learning requiring pedagogy and other critical perspectives may give ground to consider other, alternative goals instead of using sophisticated tools.

However, **Mike Zenanko** has argued there will not be any ‘model of thinking about a thing as prescribed in some learning theory’. He has based his argument on Eisner, N/A.

Alex Heneveld who is also researching in the field of learning styles and learning theories has provided us with the following references: Alkhalifa & AlDallal, 2002; Albalooshi & Alkhalifa, 2002; Alkhalifa & Albalooshi, 2003.

Lorraine Fisher and her colleagues have undertaken an informal and unstructured survey in which they found that academic staff based their choice of a ‘Model’ on cognitive needs of the student, university or organisational policies and curriculum design epistemologies. Based on the fact that present research revisited this field, the research question looked at well cited models in the educational literature such as Chickering & Ehrmann, 1996, Chickering & Gamson, 1987, and Kruse, 2004.

Lorraine Fisher has indicated that the author in Laurillard, 2002 addresses valuable research questions and that Laurillard, 2002 is highly appropriate with particular research approaches in mind. She believes that one could claim that a best practice ID model is that which satisfies the learning outcome such as cognitive, behavioural, and alike. In her opinion, a good and practical model is one that can be replicated and re-tested.

With this regard, Lorraine Fisher has provided us with the following, additional references: Ryder, 2003; UCCS, 2002; Ayersman, 2003; PennState, N/A; University of Florida, N/A; Barba, 1997; Lee & Lee, N/A; Grasha, N/A; DoIT, 2003; University of Missouri, 1997; Clark, 2000; Ryder, 2004a.

Referring to numerous postings, Lorraine Fisher has concluded that all theory could well be a representation and collocation of beliefs and experiences (conscious and unconscious) that are metamorphosed into a ‘concept’ when applied to research would be either ‘defined, defended or dismissed’ by academic peers. By removing the constraints of theory, ID becomes a process, which can be ‘defined, defended or dismissed’ and follows the rules of philosophy, which are then ‘defined, defended or dismissed’ (creating theory) and lead to ‘Lego’ components to create a model, which can be embedded as part of a research processes, then applied in practice.

7.2 Post-discussion Summary held at the Instructional Technology Forum

Terri Buckner has raised the lack of clarity concerning the use of definitions/language as well as issues of confusion between learning theories, theories of social interaction, instructional theories, and programming processes.

Terri Buckner claims that the term e-Learning seems to have been adopted for everything these days. Based on Terri Buckner’s background in higher education, e-Learning means anything from hybrid courses i.e., face-to-face and online, to revenue generating courses outside the academic credit model. With regard to the discussion paper, Terri Buckner has been wondering if the use of the term e-Learning could be narrowed to specify a digital environment.

As for mixing theories, Terri Buckner refers to Suchman, 1987’s theories which are associated with socially constructed interactions. The use of such theory in conjunction with the design of self-contained instructional objects offered via a digital environment has seemed like a suitable fit except that Terri Buckner does not see there is a role for instructors or other students in the definition of the paper of an e-Learning artefact.

With regard to an artefact, Terri Buckner thinks of it from an assessment perspective as of an object e.g., a written paper, discussion, graphic, formula, and video that represents an attempt to meet a particular goal. Furthermore, Terri Buckner also perceives an artefact as the outcome of what students produce, not what a programmer/instructor would design.

From this point of view, Terri Buckner has addressed the need to differentiate between and provide definitions for both an artefact and an object. Based on the literature, Terri Buckner has thus argued that an object is something a student acts upon while the output of this interaction yields an artefact. In this sense, Terri Buckner thinks that an LO is built around AI technology. Hereto, Terri Buckner has questioned if a social constructivist theory applies to AI and if a learner's interaction with a database can be considered a social interaction.

In Terri Buckner's opinion, it will be difficult to replace a content expert with a digital artefact even if we used AI because content matters because the interaction between pedagogy, learning theories, and content is claimed to be the basis for a dynamic learning environment. Learning theories as well as sociocultural theories are broad generalisations of how people might be expected to behave under certain conditions. Pedagogy consists of theories of instruction which Terri Buckner considers as generalisations and theories are always generalisations. Generalisations propose generalised guidelines for developing materials/resources/environments in which learning is possible.

A further concern addressed by Terri Buckner is related to the discussion of excluding content from a computer-based e-Learning system. Should content be generic where the benefit of a generic view would be adaptivity? Therefore, Terri Bucker has questioned how realistic adaptivity is and has been wondering about suggestions and guidelines for how all instruction, regardless of the content, should be developed. Terri Buckner therefore believes that Rowley, 1997's work on AI says that content does play a role but perhaps not at the level of granularity that we generally use (the instructor expert). For additional exploration, Terri Buckner has recommended further investigation of the concept of electronic support systems.

Divina Casim has reported that the term e-Learning in Korea encompasses all types of learning using electronic devices either with analogue or digital content and the hybrid of face-to-face or c-learning and online learning stands for blended learning.

Bruce Jones has also addressed the need to define the meaning of an artefact but has decided to arbitrarily accept the term artefact as a product of education and the 'object/pathway' leading to education. Bruce Jones has been querying if an artefact could be understood as a learning artefact utilised many times to build the same or different learning experiences.

For a further basis of understanding the meaning of the term artefact, Bruce Jones has referred to "a man-made object taken as a whole" (TheFreeDictionary.com, 2004) under a contextual umbrella (cf. Brown, 1995), and that "The point that mass stupidity and self-adsorption is a deliberate educational artefact needs to be hammered in" (FreeRepublic, 2004). Bruce Jones claims that the confusion about artefacts when used in an educational sense is real and obstructing. Most of us have heard the word in our studies and have used the word in our writing but there appears to be a contextual, cultural, and professional education disparity about the meaning. Bruce Jones welcomes the term artefact as the product of a course of study used to enhance or assist in future study because 'we stand on the shoulders of those who went before' which means that we learn through the use of educational artefacts of earlier study.

In regard to an 'intelligent e-Learning artefact', Bruce Jones has asked the discussion list to consider if an 'intelligent e-Learning artefact' should be regarded as an AI LO that is able to recognise progress and respond with appropriate remediation, or if it should be considered as a constructivist data base of non-related entities that are brought together as the learner interacts with the lesson to formulate new knowledge.

In response to question 6.1 Bruce Jones agrees with Terri Buckner on the need to differentiate between a system and an artefact while he thinks the answer to the question 6.1 should be a verbal description of a VIN diagram.

The whole process, as Bruce Jones sees it, is shaped like a triangle, going from broad and general statements to very narrow and specific content presentation. In the case that this is an acceptable model for a 'system', all learning entities should have a common set of foundational artefacts or knowledge objects both establishing and being defined by, the curriculum. As specific knowledge content becomes a requirement the field of study narrows to specific content i.e., artefact, LO, and its appropriate delivery.

Bruce Jones does neither thinks social constructivist theory applies to AI nor is a learner's interaction with a database social interaction. Interaction relates to "Communication between people" (cf. Webster-dictionary, 2003), social is "Inclined to seek out or enjoy the company of others; sociable" (cf. Dictionary.com, 2004) while, however, interaction is "Mutual or reciprocal action or influence" (cf. Webster-dictionary, 2003). On such basis of argumentation, Bruce Jones claims that if we step back from the mechanistic view point of a database as a collection of data points of bits and bytes and consider it to be an entity with a learning or social disorder i.e.:

- non-communicative unless queried directly which means that it will not volunteer knowledge unless asked specifically;

- giving answers based on a data embedded into a relational schemata and what it knows without constructive associations which indicates that it cannot associate non-content specific data nor make an intuitive connection; and
- ‘single-minded’ which means it can only query databases of specific content one at a time;

Then, ‘social’ takes on a radically different and more simplistic meaning. To him, ‘social’ then becomes a ‘content limited association’ that is ‘bounded by literal translation of input and output’, which could be considered as a working definition of human-database ‘social interaction’. So, LO respectively artefacts query single or multiple databases based on limited input to return content specific information which the learner can use to build knowledge i.e., much alike a search engine that then allows the learner to contribute new data to both personal and publicly shared databases. According to him, this could be said to be socially interactive.

In response to question 6.2, Bruce Jones believes that pedagogical and psychological validity is inseparable (cf. question 6.2 a)) and that the answer to question 6.2 c) is sociocultural theory (cf. Ryder, 2004b).

Further to the discussion on knowledge architecture, Bruce Jones refers to Quinn, 2004’s Knowledge System Architecture. Beyond Lorraine Fisher’s issue regarding ‘fear of technology’, Bruce Jones has drawn our attention to accuracy of present work of industry leaders by having pointed us to Microsoft, 2004’s project on “Windows Automotive”.

Further to the assertion about the social nature of interaction, **Terri Anderson** concludes that interaction can also be used to describe learner-content ‘mutual action’. Contrary to older conceptions of content, LO or databases being mechanistic or unchanging, Terri Anderson reminds us of games and simulations where the learner and the content are both changing in response to other entity’s action. These interactions may not be described as social because the term ‘social’ can depend upon the definition one uses. Therefore, social constructivist theory does apply to AI.

In response to Bruce Jones’ criteria on entities of a database, Terry Anderson believes that these are not characteristic of such active LO as results of the work of Kurzweil, 2004 are still pending.

Kurt Rowley has welcomed the anthropological-philosophical viewpoint and suggests that the type of e-Learning object and e-Learning artefact discussed in the paper could be identified as an ‘intelligent LO’. Kurt Rowley agrees with the idea that the definition of a LO or as quoted ‘any artefact of e-Learning’, should be expanded to allow it to be more intelligent in the sense of AI to reflect more of what is known about teaching and learning. That is a difficult but important goal in the AIED field because we are only in the beginning, and to tie everything together and create intelligence would require an agreed-upon ‘unified theory’ that presently does not exist, and may be some advances in distributed forms of AI.

With this respect, Kurt Rowley proposed a related idea several years ago, which, at that time, was regarded as futuristic. Nevertheless, Kurt Rowley now sees this as a vision that can orient our thinking but may not be achieved for some time (cf. Rowley, 1997).

Furthermore, Kurt Rowley believes that there are many answers on how to effectively build and construct e-Learning environments, and thus the LO, or 'artefacts'. However, this knowledge is distributed in the broader education research community. According to him, there are countless studies that provide some useful information about implementing the many paradigms of learning and teaching. He therefore refers to research in areas of computer science, human factors, management, educational research, secondary education, educational computing, and others that

- review a learning theory and/or teaching approach,
- build a teaching technology,
- test that technology;
- present the results, and
- draw conclusions about how to effectively build and construct 'e-Learning' environments.

As designers, however, Kurt Rowley argues that we should be mining this kind of research, and helping the greater e-Learning community to follow effective design processes as they build e-Learning courseware that is based on all learning and teaching strategies that are known to be effective. Our contribution can be to help them apply a systems discipline as the work through the complex and non-linear, opportunistic process of design.

With regard to the sociocultural aspects of the discussion paper, **CLFLM** has addressed the need to include and discuss very relevant literature on artefacts such as Postholm, Pettersson, Flem, Gudmundsdottir et al., 2002 and Postholm, Pettersson, Flem, & Gudmundsdottir, 2002. Sociocultural theory (or theories), though by no means very new, has recently received quite a lot of attention inside/outside academia (cf. John-Steiner & Mahn, 1996).

Under the discussion criteria of understanding the meaning of artefacts, CLFLM has referred us to reflect on Viseu, 2000b's paper while arguing that one might also encourage educational/instructional practitioners' to think critically when designing/developing new technologies for educational/instructional purposes (cf. Viseu, 2000a).

In consequence, CLFLM observes that there might not be anything inherently wrong in theories or technologies themselves, but instead of following, chasing or even being entangled with theoretical or technological trends, educational practitioners might need to always remind themselves of our main aim or mission, i.e., to try to improve or enhance both teaching and learning for the benefits of both teachers and learners. Otherwise, we might run the risk of 'putting the cart before the horse'. Therefore, no matter what theory/theories to be adopted/adapted, learning technologies should be considered as the means by which we try to fulfil our general aim i.e., to improve teaching and learning. If this aim is clear to us as educational/instructional practitioners, any theories or technologies might somehow be of secondary importance (cf. Wilson, 1997).

Stephen Downes has raised issues of emotional factors in learning like e.g., anger, which, though computationally not identifiable, is nonetheless real. To Stephen Downes, learning is a lot more like anger than it is like the post that carried it. While the post may be computationally identifiable, the learning is not, and it is arguably a reductionist fallacy to suppose that it is.

According to him, the language of 'LO' or 'artefacts' and of 'constructing' or 'building' knowledge is misleading because we would not talk of 'building' anger in another person, nor of an 'anger delivery system', yet the very purpose of online communications is to engender anger or for example, love, happiness, or learning. And when we think of it that way, we realize, that just as there is no clearly identifiable, universal, definable, or concrete way of producing anger (or love, or happiness) in a person, the same also is true of learning. An irreducible element of learning is the prior mental state of the person. This makes learning impossible to define computationally but not impossible to do with computers.

As an example, Stephen Downes suggests us to consider the sort of enquiry method a photocopier uses to teach its human operators. In her discussion of the failure of such 'computer-based teaching', Suchman, 2000 argues that at least part of the failure is due to the fact that "the machine had access only to a very small subset of the observable actions of its users" (Suchman, 2000, p. 3). Viewed in this way, the problem becomes one of giving the machine access to a wider range of stimuli, so that it is better able to understand the context in which the learning is taking place i.e., the situation in which the situated cognition is occurring. The machine, as an artefact conveying (but not containing) the designer's knowledge of how the machine functions, must be designed in such a way as to be able to read, and react to, the situation in which learning occurs.

Stephen Downes argues that the sort of concept, then, that we are looking at is a sort of AI for the design of autonomous LO. One way of doing this - the method that failed in Suchman, 1987's account, is to give the users a set of rules to follow. He claims, this is essentially the approach taken by IMS Global Learning Consortium, 2004.

Instead, then, of a list processing approach to the sort of AI such a machine would require, we turn to the architecture suggested by an events based processor. On this model, different scripts, different routines, are brought into play depending on the nature of the learner and the circumstances in which the learning is taking place. If Learning Design is like a play, in which the student actors follow a script, then this model is like a game, in which the learners are participants, seeking a means to accomplish an objective, with the photocopier responding appropriately and helpfully. Suchman, 2000 argues that "I often found myself in the position of being able to 'see' the difficulties that people were encountering, which suggested in turn ideas of how they might be helped. If I were in the room beside them, in other words, I could see how I might have intervened" (Suchman, 2000, p. 3).

This second sort of task is no less immense, even if we could give the photocopier full access to the entire situation in which the learning is taking place (and indeed, for each new bit about the situation, the complexity of the instructional system would increase exponentially). He argues that it would take a million dollar computer system to provide instructions on how to use a five thousand dollar photocopier. This is why he thinks, people ‘drop their jaws’ at the idea that such a thing could be done, and why to some the request for a greater and more precise specification of the learning outcomes, pedagogical model, and other computational structures, seems only to increase the impossibility of the task, not to clarify it.

These considerations have led Stephen Downes to conclude that the learning process cannot be in the LO. If the LO is an artefact, that which acts as a carrier or representation of the knowledge of the original designer of the photocopier (or, at least, someone who knows how to use it), it cannot by itself accomplish this task. The LO cannot do what Suchman, 2000 says is so easy for her, to observe what they are doing wrong and offer suggestions. The LO is what is presented when questions of situation - both in the environment and specific to the learner - have ‘already’ been resolved. The LO - a map - may be a representation of the domain, but will only partially reliably guide the learner. To Stephen Downes the question is not, “could a LO ever determine an appropriate response?” because a LO is not the sort of thing that determines responses. The only equivalent question, in his opinion, from the standpoint of computers, is to ask, “could a computer network ever provide an appropriate response?” or more specifically, “could the internet ever provide the appropriate response?” Stephen Downes thinks that the answer to this question is “yes” - yet argues that it is “yes” conditionally; that is, it depends on our having a correct understanding of the internet. The appropriate understanding of the internet, in his view, is to picture it as a vast communications system. To stimulate learning, a communication must have its origin in - and therefore the capacity to cause - an emotional response which means that we want to know a person’s thought, not a data structure.

Therefore, Stephen Downes believes that it is not a question of putting the pedagogy into the system, which means it is not a question of creating exactly the right sentence. Rather, to him, it is a matter of giving a channel through which to flow. It is a question of making the right connection between one person and another person, and of determining how these people can exchange information in the right way. Stephen Downes believes that if we get the ‘communication’ right, the learning will take care of itself.

Clark Quinn has argued that many of the installations of the standard LMS (e.g. WebCT, newly IPO'd Blackboard) are being used by faculty who have received little pedagogical preparation, and have insufficient support. The typical path, it appears, is that such faculty first put their lecture notes up, and over successive semesters, they start taking advantage of other features.

As with regard to LO and critical view points (cf. IEEE Technical Committee on Learning Technology, 2004) towards their present perceptions, Clark Quinn has provided us with a reference discussing smart objects (cf. Quinn, 2000).

With regard to the discussion on AI, the role, the interaction and social perception of an intelligent, psychologically and pedagogically valid e-Learning system, **Lorraine Fisher** has argued that the fear of using computers and computer anxiety is still very real and cannot be ignored in educational technology.

With regard to a question by author enquiring about formal and mathematical/algebraic/logical work on the understanding of the relation attributes of the DCMI (cf. DCMI, 2003b; DCMI, 2003a) which are relevant to the commonly known LO paradigm, **Andrew Deacon** quotes that he has also been confused as to why LO were not drawing on richer abstract models as generalised in Object Modelling. In answer to a question from the author, Andrew Deacon states that he has also been confused as to why LO were not drawing on richer abstract models as generalised in Object Modelling. These models are represented by the attributes of DCMI (cf. DCMI, 2003b; DCMI, 2003a) as they relate to Mathematic and other logical systems. Hao-Chuan Wang and the author provided citations by Daniel Rehak at CMU (cf. Learning Systems Architecture Lab, 2004) in support of their stance. One of the points made there is that LO were developed for vendors and publishers, not educators, learners or anyone else. The implication seems to be that more or different tools enforcing relations and adding intelligent behaviours are needed (they may import and export LO). There are other interests too, such as supporting developers and assessment/feedback workflows that will need their own special relationships. Andrew Deacon’s understanding of the research in business workflows is that non-trivial actual workflows are so complex to model that no simple formalism exists which can be efficiently and unambiguously implemented. Statecharts are an example of a balance between power of expression and simplicity of execution (note by the author: Statecharts contain state reaction, state hierarchy, and parallelism as outline by Wieringa, 2003). Therefore, in practice there are many representations and methodologies - a plethora of tools and many expensive consultants. In the education field, there may well be things that can be exploited to keep everything much simpler.

Andrew Deacon has been investigating how frameworks such as sakaiproject.org, 2004 and other portal technologies will make it easier to execute dependencies - by making more events accessible than, in a generic web environment. One of the examples cited was the ability to ask a survey or quiz question when some or other resource had viewed to the end. As Stephen Downes noted, we cannot hope to build-in everything to behave intelligently, but we do need more information about what students are doing. This is important so we can provide the guidance we would have provided if we had been teaching them individually. Such mechanisms are not unique to the needs of education, thus we should benefit from work (and failures) elsewhere.

8. For future Discussions

Further exploration on the first question could look at the distinctions between conventional systems development and soft systems methodology of e-Learning artefacts. Also, as clearly addressed by the discussions, there is a need to research on the differentiations between an artefact, intelligent artefacts, a system, LO, and intelligent LO. Further research will be needed to specify the degrees of influence of sociocultural theory, philosophy, epistemology, and anthropology affecting the behaviour, construction, and cognition of artefacts, systems, and (intelligent) LO. Further development, based on the situated facets of e-Learning artefacts and the outcome of systems development methodologies need to be contrasted in view of requirements analysis and elicitation. Practical realisation would therefore need to investigate on the ‘pedagogical and psychological ideal situations’ and contrast these with the today’s technological possibilities. Hence, future discussion will be needed to encourage intensified discussions among multiple research disciplines such as computer science, psychology, AI, and pedagogy.

As with regard to the second and third questions, we could well explore further the distinctions and needs of different levels of pedagogical and psychological validity and their implications e.g., at the level of LO, at the object, artefact, and system level as well as at the system level by distinguishing various categories. Further study will be needed to compare artefacts and systems by exploring constructivist, behaviourist, and cognitive facets of databases and intelligent/adaptive systems under the light of AI. Nor have we discussed the meaning and essence of ‘pedagogical and psychological validity’. Expanding on the arguments of Hao-Chuan Wang, how do we relate ‘pedagogical and psychological validity’ to e-Learning systems or computers in education? What should their objectives be? Pedagogical and psychological validity may also represent other perspectives such as a user perspective i.e., exploring the question of how to incorporate emotional factors in learning into an e-Learning artefact and how an e-Learning system could stimulate learning?

Neither the fourth or fifth questions have not been explored. These questions leave further space for discussion and research into technical realisation of purposeful actions and plans and how their relationships with learning theories. An interesting extension in research would certainly need to build distinctive classes of learning theories to discuss their applicability in both the technical and psychological domains.

Last but not least, both discussions have been extremely rich and reveal many future research opportunities. In particular, the author would like to thank the participants for the vivid participation and valuable observations and for the many, “… insightful inquiries and analysis help[ing] us to focus on tomorrow by what we see today” (Bruce Jones) as “… our [instructional designers and technologists] main aim or mission is to try to improve or enhance both teaching and learning for the benefits of both teachers and learners” (CFLM).

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Ontologies and the Semantic Web for E-learning

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The *Semantic Web* is the emerging landscape of new web technologies aiming at web-based information and services that would be understandable and reusable by both humans and machines. *Ontologies*, generally defined as a representation of a shared conceptualization of a particular domain, is a major component of the Semantic Web. It is anticipated that Ontologies and Semantic Web technologies will influence the next generation of e-learning systems and applications.

To this end, key developments such as

- *formal taxonomies* expressed, e.g., with the help of the web ontology languages RDFS and OWL, and
- *rules* expressed, e.g., with the help of the web rule language RuleML,

are expected to play a key role in enabling the representation and the dynamic construction of shared and re-usable learning content.

The aim of this special issue is to explore topics related with the new opportunities for e-learning created by the advent of Ontologies and the Semantic Web.

Presentation of the Special Issue

With an acceptance rate of 25% an intensive two-blind review process concluded to the final acceptance of 4 full research papers covering several key themes in the Semantic Web and E-learning research agenda. We decided to invite 4 more papers from international well known academics that have demonstrated excellent research outcomes in the exploitation of Semantic Web and ontologies for e-learning.

The eight published papers cover a wide range of research problems in Semantic e-learning. We tried to have a balanced approach in which readers of this special issue will not only gain a state-of-the-art literature review but also will be able to understand the design and development of real world applications, prototypes and tools of e-learning in the Semantic Web.

Table 1. Special issue at a glance

Authors	Title	Key Issues	Contribution
Devedzic	Web Intelligence and AIED (invited)	Intelligent Web services, Semantic markup, and Web mining	Exploiting SW for tackling new and challenging research problems in AIED
Cristea	What can the Semantic Web do for Adaptive Educational Hypermedia? (invited)	Adaptive Hypermedia	A conversion method from Adaptive Hypermedia to the Semantic Web
Aroyo and Dicheva	The New Challenges for E-learning: The Educational Semantic Web (invited)	Interoperability among various educational systems Automated, structured and unified authoring support Semantic conceptualization and ontologies	State-of-the-art research A realistic approach towards the Educational Semantic Web
Yang, Chen and Shao	Ontology Enabled Annotation and Knowledge Management for Collaborative Learning in Virtual Learning Community (invited)	Virtual Learning Communities Personalized annotation Semantic Content Retrieval	Two metadata models, content model and annotation
Henze, Dolog and Nejdl	Reasoning and Ontologies for Personalized E-Learning in the Semantic Web	Ontologies and metadata for three types of resources (domain, user, and observation)	Framework for personalized e-Learning in the semantic web A logic-based approach to educational hypermedia using TRIPLE
Abel, Barry, Benayache, Chaput, Lenne and Moulin	Ontology-based Organizational Memory for e-learning	Integration of Ontologies Knowledge engineering Pedagogical design Organizational memory, Topic maps	An ontology building process An Ontology-based Organizational Memory for e-learning
Moreale, Vargas-Vera	Semantic Services in e-Learning: an Argumentation Case Study	Semantic Services Argumentation	An architecture for Semantic E-learning Services
Papasalouros, Retalis and Skordalakis	Semantic description of Educational Adaptive Hypermedia based on a Conceptual Model	Conceptual Modeling Hypermedia Design	CADMOS-D: A Hypermedia Design Method Method for transformation of UML modeling to Semantic Description

In the first paper entitled "*Web Intelligence and AIED*", Vladan Devedzic, surveys important aspects of Web Intelligence (WI) in the context of AIED research. WI explores the fundamental roles as well as practical impacts of Artificial Intelligence (AI) and advanced Information Technology (IT) on the next generation of Web-related products, systems, services, and activities. Author argues that the key advantages of applying WI techniques to AIED are enhanced adaptivity and enhanced learner comfort. WI enables course sequencing and material presentation not only according to the learner model, but also according to the most up-to-date relevant content from the Web. Automatic discovery, invocation, and composition of educational Web services can free the learner from many time-consuming activities that often disrupt the learning process itself. Finally, ontology-supported learning process greatly increases automation of a number of learners', teachers', and authors' activities related to Web-based learning environments.

In the second paper entitled "*What can the Semantic Web do for Adaptive Educational Hypermedia? (invited)*", Alexandra Cristea, argues that "Semantic Web and Adaptive Hypermedia come from different backgrounds, but it turns out that actually, they can benefit from each other, and that their confluence can lead to synergistic effects". Towards this direction the paper demonstrates how LAOS, an Adaptive Hypermedia (authoring) framework can be used in the context of the Semantic Web.

In the third paper entitled "*The New Challenges for E-learning: The Educational Semantic Web (invited)*" Lora Aroyo, and Darina Dicheva, outline the state-of-the-art research on Semantic E-learning and suggest a way towards the Educational Semantic Web. They propose a modular semantic-driven and service-based interoperability framework and related ontology-driven authoring tools. The challenge of the next generation web-based educational systems is to support user-friendly, structured and automated authoring, balancing between exploiting explicit semantic information for agreement and exchange of educational information, and on the other hand, collecting and maintaining the information semantics.

In the fourth paper entitled "*Ontology Enabled Annotation and Knowledge Management for Collaborative Learning in Virtual Learning Community (invited)*", Yang, Chen, and Shao propose a framework for ontology enabled annotation and knowledge management in collaborative learning environments. Personalized annotation, real-time discussion, and semantic content retrieval are the three main elements of the proposed semantic web services.

Henze, Dolog, and Nejdl in their paper "*Reasoning and Ontologies for Personalized E-Learning in the Semantic Web*" propose a framework for personalized e-Learning in the semantic web and show how the semantic web resource description formats can be utilized for automatic generation of hypermedia structures. They investigate a logic-based approach to educational hypermedia using TRIPLE, a rule-based query language for the semantic web.

In the sixth paper entitled "*Ontology-based Organizational Memory for e-learning*", Abel, Barry, Benayache, Chaput, Lenne, and Moulin present an ontology-based document-driven memory which is particularly adapted to an e-learning situation. They provide a thoroughly discussion of a learning organizational memory and they focus on the ontologies on which it is based. Their research work is situated at the crossroad of three domains: knowledge engineering, pedagogical design and semantic web and they provide interesting insights.

Moreale and Vargas-Vera in the seventh paper entitled "*Semantic Services in e-Learning: an Argumentation Case Study*" outline an e-Learning services architecture offering semantic-based services to students and tutors, in particular, ways to browse and obtain information through web services. They present a proposal for a student semantic portal providing semantic services, including a student essay annotation service. They also claim that visualization of the arguments presented in student essays could benefit both tutors and students.

In the final paper entitled "*Semantic description of Educational Adaptive Hypermedia based on a Conceptual Model*", Papasalouros, Retalis and Skordalakis present how the outcomes of the Conceptual Design stage of a method for developing Adaptive Educational Hypermedia Systems can be encoded using RDF-based ontologies. They focus on the development of a tool for the translation of OCL rules to RuleML to facilitate the automatic transformation of UML models to Semantic Web descriptions beside XSL Transformations.

Epilogue

We would like to take this opportunity to thank the reviewers for their great efforts and all the authors who submitted their papers to our special issue. We particularly thank the authors of accepted and invited papers for their high-quality work and for having worked on a tight schedule to come up with their revised versions in a timely manner.

The reviewers for the Special issue are: Ignacio Aedo, Lora Aroyo, Felix Buendia-Garcia, Alexandra Cristea, Vladan Devedzic, Darina Dicheva, Juan Manuel Dodero, Renata S. S. Guizzardi, Fotis Kokoras, Piet Kommers, Ioannis Kompatsiaris, Erica Melis, Riichiro Mizoguchi, Wolf-Ultrich Raffel, Bernd Simon, Kateryna Synytsa, Kuldar Taveter, and Jorge Torres.

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Web Intelligence and Artificial Intelligence in Education

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Abstract

This paper surveys important aspects of Web Intelligence (WI) in the context of Artificial Intelligence in Education (AIED) research. WI explores the fundamental roles as well as practical impacts of Artificial Intelligence (AI) and advanced Information Technology (IT) on the next generation of Web-related products, systems, services, and activities. As a direction for scientific research and development, WI can be extremely beneficial for the field of AIED. Some of the key components of WI have already attracted AIED researchers for quite some time – ontologies, adaptivity and personalization, and agents. The paper covers these issues only very briefly. It focuses more on other issues in WI, such as intelligent Web services, semantic markup, and Web mining, and proposes how to use them as the basis for tackling new and challenging research problems in AIED.

Keywords

Web intelligence, Ontologies, Semantic Web, Educational Web services, Pedagogical agents.

Introduction

The scope of WI as a research field, as proposed by Zhong et al. (2002), encompasses Web information systems environments and foundations, ontological engineering, human-media interaction, Web information management, Web information retrieval, Web agents, Web mining and farming, and emerging Web-based applications. It also aims at deepening the understanding of computational, logical, cognitive, physical, and social foundations as well as the enabling technologies for developing and applying Web-based intelligence and autonomous agents systems (Liu et al., 2003).

We can study Web intelligence on at least four conceptual levels (Zhong et al., 2002):

- network level – Internet-level communication, infrastructure, and security protocols, where intelligence comes from the Web adaptivity to the user's surfing process;
- interface level – intelligent human-Internet interaction, e.g. personalized multimedia representation;
- knowledge level – representing (in machine-understandable formats) and processing the semantics of Web data;
- social level – studying social interactions and behavior of Web users and finding user communities and interaction patterns.

Although WI certainly overlaps with other research fields and directions, the keyword here is deepening – WI covers some more specific and emerging issues related to otherwise broad, general fields. For example, WI researchers (http://wi-consortium.org/) are interested in manipulating the meaning of data (i.e., machine-understanding and machine-processing of data items, entities, and their relationships), means of creating distributed intelligence, balance between Web technology and intelligent agent technology, agent self-organization, learning, and adaptation, agent-based knowledge discovery, agent-mediated markets, autonomy-oriented or autonomic computing, security issues in Web and agent systems, Semantic Web, Web services and interoperability, grid computing technology, emergent behavior, knowledge management, networks, and communities, ubiquitous computing, and social intelligence.

In education, we should pay close attention to such developments and trends. This paper surveys some of the important issues related to WI, and discusses their implications for Web-based teaching and learning. It also presents the background and context for developing WI-empowered educational systems, describes the current state of the development, indicates some existing applications and tools, and introduces some research issues stemming from numerous possibilities for cross-pollination between WI, IT, and AIED.

Semantic Web

An important part of the background and context for discussing the relationship between WI and AIED is the Semantic Web (http://www.semanticWeb.org/). It is the new-generation Web that makes possible to express information in a precise, machine-interpretable form, ready for software agents to process, share, and reuse it, as well as to understand what the terms describing the data mean. It enables Web-based applications to interoperate both on the syntactic and semantic level (Hendler, 2001).

Key components of the Semantic Web technology are (Preece and Decker, 2002):

- a unifying data model; currently, RDF (Resource Description Framework, http://www.w3.org/RDF/) is most frequently used data model on the Semantic Web;
- ontologies of standardized terminology to represent domain theories; they enable construction of support tools that assist the generation and processing of semantic markup of Web resources;
- languages based on RDF, such as DAML+OIL (DARPA Agent Markup Language plus Ontology Inference Layer), http://www.daml.org/2001/03/daml+oil-index, for developing ontologies and for marking up Web resources; semantically annotated Web resources, in turn, enable semantically rich service-level descriptions (such as DAML-S, the DAML-based Web Service Ontology, http://www.daml.org/services/).

Ontologies and semantic markup are the core of the network of knowledge on the Semantic Web, because marked up Web pages point to ontologies and ontologies point to each other, Figure 1.

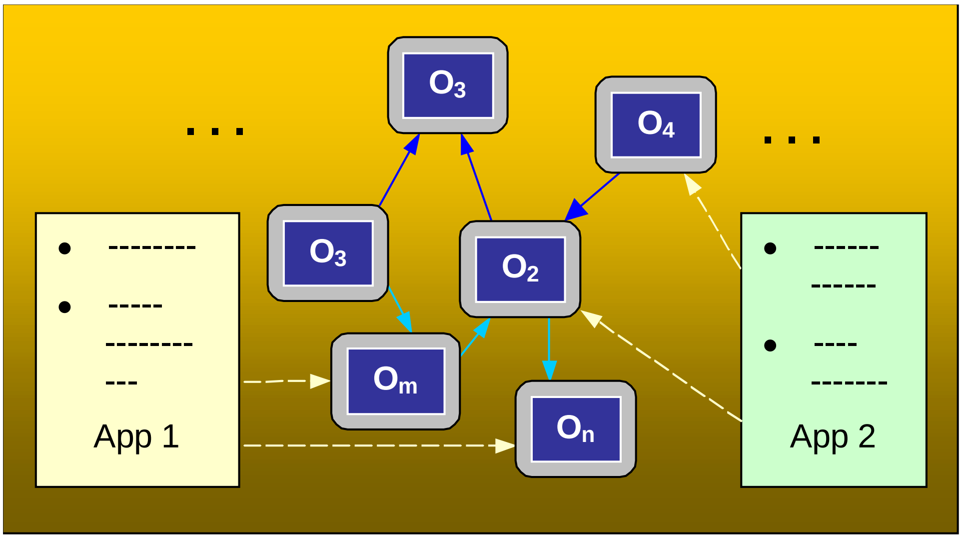

Figure 1. Semantic markup provides mappings between Web pages and ontologies (Oi - ontologies)

Languages

There are a lot of languages for developing ontologies and semantically annotating Web pages. One way or another, most of them are based on XML (eXtensible Markup Language), XML Schemas, RDF (Resource Description Framework), and RDF Schemas, all four developed under the auspices of the World-Wide Web Consortium (W3C) and using XML syntax (Gómez-Pérez and Corcho, 2002). Another important branch of languages is that for supporting WI-infrastructure issues, such as WSDL (Web Services Description Language), WSFL (Web Services Flow Language), UDDI (Universal Description, Discovery, and Integration), SOAP (Simple Object Access Protocol), and PSML (Problem Solver Markup Language) – see (Zhong et al., 2002; Liu et al., 2003; Preece and Decker, 2002) for starting points on the use of these languages to support development of WI.

The most recent relevant facts related to the language issues are the following:

➢ Web Ontology Language, or OWL (http://www.w3.org/2001/sw/WebOnt/), the language developed by W3C for representing ontologies on the Web in an XML-based syntax became a W3C recommendation on 10th February 2004;

- Web Services Description Language v2 (WSDL) was published on 10th November 2003.

WI-related Work in AIED

AIED community has already started studying a number of issues generally relevant to WI. Of course, AIED researchers study such issues in the context of teaching and learning theories and systems. For example, there is an extensive research and development effort in pedagogical agents, autonomous software entities aimed at supporting human learning by interacting with students/learners and authors/teachers and by collaborating with other similar agents, in the context of interactive learning environments (Johnson et al., 2000). Pedagogical agents can help very much in locating, browsing, selecting, arranging, integrating, and otherwise using educational material on the Web.

The work in Web-based intelligent tutoring systems (ITS) also has a long tradition. Web-based ITS are generally important for WI since they demonstrate how different intelligent techniques can be deployed to support a number of issues highly relevant for the learning and teaching processes on the Web, such as personalization, adaptivity, and collaboration, to name but a few. Although in Web-based ITS all such issues are learner-centered, their importance overcomes the domain of education. With some effort, parts of the Web-based ITS technology can be transferred to other application domains.

First-wave Web-based ITS like ELM-ART (Brusilovsky et al., 1996) and PAT Online (Ritter, 1997), to name but a few, were followed by a number of other learning environments that used Web technology as means of delivering instruction. More recent Web-based ITS address other important issues, such as integration with standalone, external, domain-service Web systems (Melis et al., 2001), using standards and practices from international standardization bodies in designing Web-based learning environments (Retalis and Avgeriou, 2002), and architectural design of systems for Web-based teaching and learning (Alpert et al., 1999), (Mitrović and Hausler, 2000). Rebai and de la Passardiere try to capture educational metadata for Web-based learning environments (Rebai and de la Passardiere, 2002).

A rapidly growing branch of AIED research is teaching and learning ontologies and ontology-aware authoring tools. Generally, ontologies provide the necessary armature around which knowledge bases should be built, and set grounds for developing reusable Web-contents, Web-services, and applications (Devedžić, 2002). The most notable classical work in the AIED community related to the development of educational ontologies comes from the Mizoguchi Lab at Osaka University, Japan (e.g., see (Mizoguchi and Bourdeau, 2000)), and from Tom Murray (1998).

In order to better justify some of the WI-related issues stipulated in the remaining of the paper, it is also important to mention the idea of educational gateways and portals, such as GEM (the Gateway to Educational Materials), http://www.geminfo.org. Started as a U.S. Department of Education initiative, GEM is a teacher-oriented educational portal that "expands the educator's capability to access Internet-based lesson plans, curriculum units and other educational materials" by providing "The Gateway" to well-organized, quality collections of various educational resources related to different fields of study. GEM does not use ontologies yet, but makes good use of metadata (specified in RDF), such as title, description, grade levels, resource type, and so on.

Setting for WI-AIED systems

Figure 2 shows a likely setting for teaching, learning, collaboration, assessment, and other educational activities on the Web supported by WI (Devedžić, 2003). Educational material may be distributed among different *educational servers* – specific Web applications running on physical servers and responsible for management and administration of, as well as access to the material. As with educational gateways and portals, teachers and learners can access the educational material residing on educational servers from the client side. However, unlike educational gateways and portals it is pedagogical agents that are supposed to provide the necessary infrastructure for knowledge and information flow between the clients and educational servers. On behalf of learners, pedagogical agents should access *educational content* on the servers by using high-level e*ducational services*. Educational content is any educational material pedagogically organized and structured in such a way that interested learners can use to get introduced to a knowledge domain, deepen their understanding of that domain, and practice the related problem-solving skills. Educational service is a Web service designed specifically to support a learning or teaching goal (see the sections "Intelligent Web Services" and "Intelligent Educational Servers and Portals" for details).

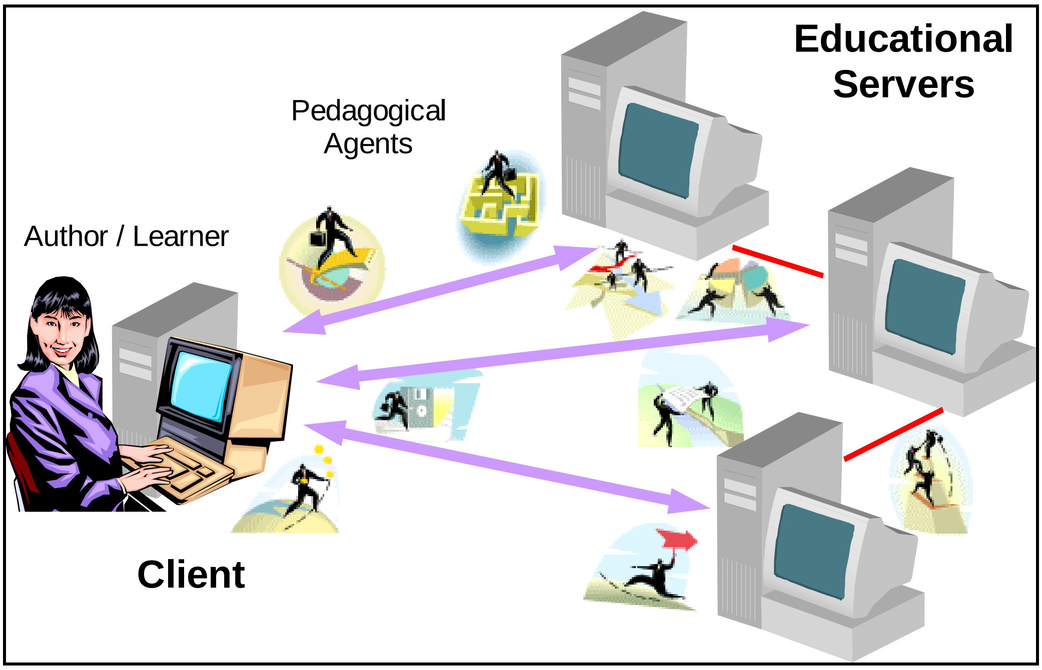

Figure 2. The setting for Web-based education

Educational servers should be created to possess enough intelligence to arrange for *personalization* of the learning tasks they support. In fact, from the learner's perspective the server should appear to act as an intelligent tutor with both *domain* and *pedagogical* knowledge to conduct a learning session. It should use a *presentation planner* to select, prepare, and adapt the domain material to show to the student. It also must gradually build the *student model* during the session, in order to keep track of the student's actions and learning progress, detect and correct his/her errors and misconceptions, and possibly redirect the session accordingly.

It is easy to map Figure 1 onto the setting shown in Figure 2 – Web-based educational applications and services on the Semantic Web can reside on different educational servers, yet they can be easily interconnected and semantically integrated based on the network of ontologies. Semantic markup of educational material, Web pages, and other learning resources should be done by using appropriate tools. Ideally, such tools should be integrated with authoring tools, transparent to the learning material author, and should let him annotate his Web-based learning material automatically, as part of his everyday work, without even thinking about semantic markup. The Briefing Associate tool (Tallis et al., 2002) and ITtalks application (Scott Cost et al., 2002) are good examples of how to design and use such tools.

The following sessions elaborate on the setting from Figure 2 and some of its important concepts in the context of WI.

WI and Personalization of Learning

Adaptivity of Web-based systems plays an important role in WI (Liu et al., 2003). Important issues related to adaptivity of Web-based learning environments, such as providing adaptive navigation support to the learner, links annotation, and adaptive curriculum sequencing, have been already studied in the AI community (Brusilovsky, 1999). In the setting from Figure 2, an essential aspect of educational servers' adaptivity is *personalization* – they should be able to personalize interactions with each learner by keeping track of his recent visits/activities and relating the topics he learns and the sites he accesses during different learning sessions. Moreover, an intelligent educational server should actively help the learner and interact with him when executing these tasks. Since educational servers are interconnected, a specific server may personalize the session with a particular learner by pre-fetching the material the learner needs from other servers. This is an adaptive process based on observations of the learner's surfing behavior during previous sessions. It belongs to *network-*

level WI, and is different from *interface-level WI*, which is related to adaptive cross-language processing, personalized multimedia representation, and multimodal data-processing capabilities (Zhong et al., 2002).

In the AIED community, Trausan-Matu et al. have recently proposed an ontology-based approach to enhancing network- and interface-level WI within the EU INCO Copernicus project in computer-aided language learning (Trausan-Matu et al., 2002). Since the Web information on a certain topic changes dynamically and unpredictably, they extract, annotate, and integrate new information with the old one in the domain ontology, and use it along with the student model to personalize each learning session.

Ontological Engineering

Developing and deploying ontologies to support Web-based educational applications is not just a matter of domain expertise – it is an engineering discipline in itself. Ontological engineering comprises a set of activities that are conducted during conceptualization, design, implementation and deployment of ontologies (Devedžić, 2002).

A good theoretical foundation for ontological engineering of AIED systems (Mizoguchi and Bourdeau, 2000), an early ontology-aware authoring tool (Chen et al., 1998), as well as several other, practical, working ontologies and ontology-based systems (Mizoguchi and Kitamura, 2001), all developed in the Mizoguchi Lab, Osaka University, Japan, have stimulated ontological engineering of other Web-based AIED applications as well. Examples of good engineering design of ontological support for Web courseware authoring include the recently ontology-enhanced AIMS architecture (Aroyo et al., 2002) and the Ontology Editor (Bourdeau and Mizoguchi, 2002) that enables collaborative ontological engineering involving both a domain expert and an instructional-design expert.

Note, however, that developing ontologies manually is anything but easy. WI suggests automating this process by letting educational ontologies *gradually evolve* (Trausan-Matu et al., 2002) as well by *ontology learning* (Maedche and Staab, 2001). This latter idea is to use machine learning, data mining, and statistical tools to import, extract, prune, refine, and evaluate ontologies from the Web. Ontology learning can be from free text, dictionaries, XML documents, and legacy ontologies, as well as from reverse engineering of ontologies from database schemata.

Intelligent Web Services

Roughly speaking, Web services are activities allowing both end users and, under appropriate circumstances, software agents to invoke them directly (Preece and Decker, 2002). In the traditional Web model, users follow hypertext links manually. In the Web services model – and Figure 2 comprises using *that* model – they invoke tasks that facilitate some useful activity (e.g., meaningful content-based discovery of learning material, fusion of similar educational material from multiple sites, or commercial activities such as course advertising and registration for distance learning). Technically, Web services are autonomous, platform-independent computational elements that can be described, published, discovered, orchestrated, and programmed using XML artifacts for the purpose of developing massively distributed interoperable applications. Platform-neutral and self-describing nature of Web services and particularly their ability to automate collaboration between Web applications make them more than just software components.

Note, however, that in WI-enhanced Web-based ITS the idea is to employ *intelligent* Web services – to go beyond XML/RDF infrastructure of Web pages, to explore Web services that can be enabled by intelligent systems technology. With WI, the learners, the teachers, and the authors alike will be able to see the Web as if it was turned into a collection of educational resources, each with a well defined interface for invoking its services (Vinoski, 2002). We may even envision development of an education-oriented dialect of WSDL called EWSDL (Educational Web Services Description Language)! Pedagogical agents will continue to facilitate automatic service discovery, invocation and composition (Figure 2), but as educational Web services evolve, they too will acquire standard interaction models (McIlraith et al., 2001).

An example of a *service-oriented architecture* of Web-based ITS, elaborated after (Vinoski, 2002), is shown in Figure 3. Educational services should advertise themselves in the registry, allowing learners' agents to query the registry for service details and interact with the service using those details. WI community has already developed an ontology of Web services – DAML-S, DAML-based Web Service Ontology (http://www.daml.org/services/).

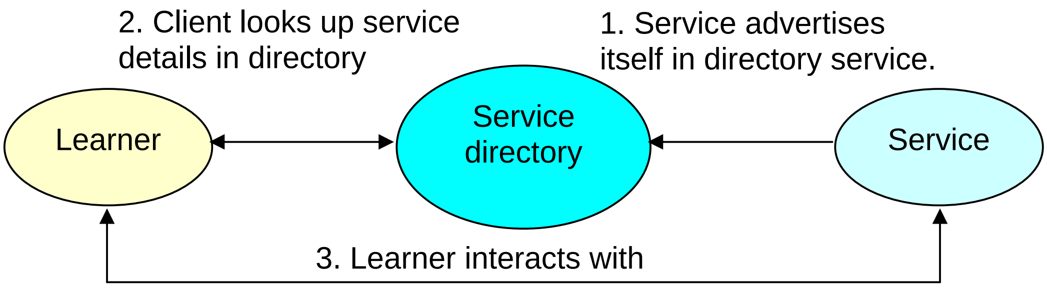

Figure 3. Service-oriented architecture of educational Web servers

Using service-oriented architecture from Figure 3 in Web-based ITS development can greatly enhance the traditional ITS development process, since the client-side system can be built based on educational Web services even if these services are not yet available or they are not known by the ITS developers. This is due to the fact that each Web service is described through a service description language such as WSDL, dynamically discovered by applications that need to use it, and invoked through the communication protocol defined in its interface. In Figure 3, the central component of the educational Web server is the service directory – an information pool pertaining to different educational services, dynamically organized, but highly structured (e.g., as a tree, or as a table/database). The underlying assumption is that at each point in time the directory lists those services that are ready to be invoked by the learner; the services are supposed to advertise their readiness and availability to the directory. Hence a pedagogical agent can find out about the available services by looking up the directory. Then it can decide whether to automatically invoke a suitable service on the learner's behalf, or merely to suggest the learner to interact with the service directly.

Intelligent Educational Servers and Portals

Summarizing the WI ideas from the previous sections, our initial proposal of the *INtelligent Educational Servers* architecture (INES) is depicted in Figure 4. The associated (non-exhaustive) Table 1 describes the services shown. An INES-based server (portal) can offer teachers, learners, and authors service-oriented access to educational content in (a) specific domain(s) of interest. Through presentation services, the content can be adaptively organized and shown in numerous ways. INES enables *knowledge-level WI* (Zhong et al., 2002) for all users: agent-based search, aggregation, classification, filtering, managing, mining, and discovery of educational material. Through agents and ontologies, INES also enables intelligent educational services to automatically self-delegate their functional roles to other services, along with their corresponding spatial or temporal constraints and operational settings (Liu et al., 2003). Note that, just like educational contents, educational services need to be semantically described by their own ontologies (e.g., ontology of assessment, or ontology of library access) and marked-up accordingly in order for pedagogical agents to locate them and invoke them when accessing Web pages of educational servers.

In order to illustrate the envisioned use of INES-based servers, consider the following hypothetical scenario. A learner is engaged in deepening his/her knowledge of Greek mythology. His/her agent realizes the learner's goal either by being told explicitly, or by observing the learner's interactions with the Web and comparing them to the learner's previous activities it knows about. Presumably, the learner's personal agent knows enough about the learner's goals or can access such information elsewhere, e.g. in the students database. The agent then contacts educational servers it knows about. Alternatively, it can contact other similar pedagogical agents it is aware of, such as a facilitator agent that may help the learner's agent find another educational server. When contacting an INES-based server, the agent first queries learning services in order to identify the ontology of Greek mythology and return it to the learner. The learner may browse the ontology and refine his/her search to the concept of *god*. The agent then invokes different learning and reference services from the INES server in order to build for the learner an initial selection of suitable and available learning resources in the form of a dynamically generated multimedia HTML page. All contents on that page are marked-up with ontological information coming from the server side. The learner may proceed by selecting *Titans* on that initial page, which triggers the agent to interact with INES services that acquire, integrate, and arrange the corresponding learning material from heterogeneous sources, build the initial learner model, and select and invoke a suitable tutor on the server side to begin the learning session. The learner's agent monitors the session and intelligently assists the learner in all administration and communication with the INES server. It also takes care of the changes in the learner's focus and dynamically checks the availability of INES services, thus making the underlying technical complexity of the session fully transparent to the learner. The learner can concentrate on his/her learning goals.

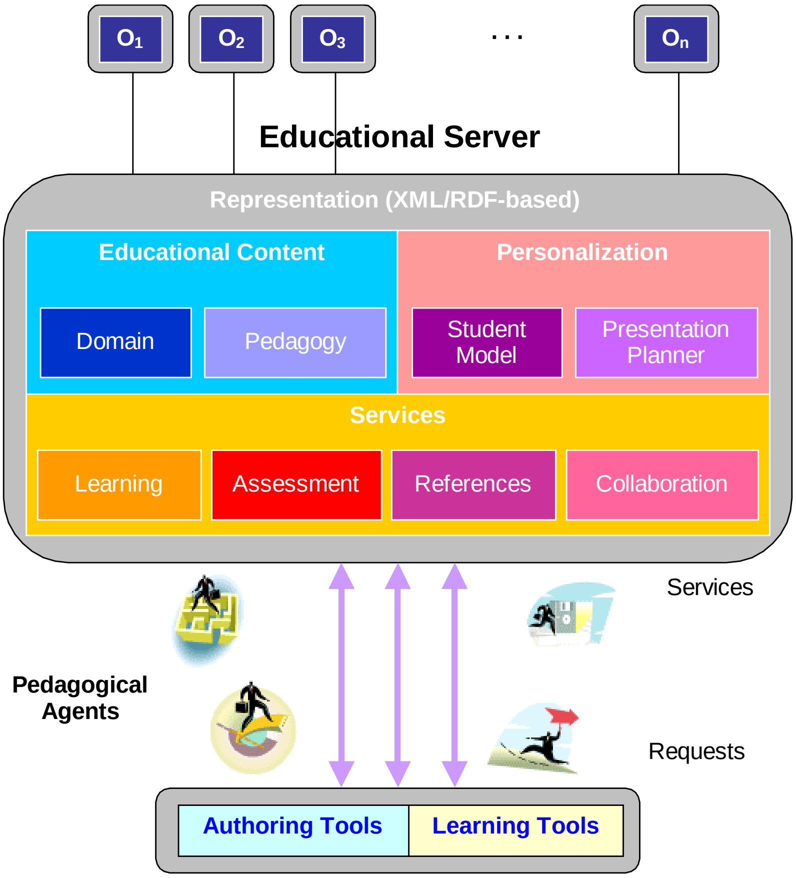

Figure 4. INES architecture: inside an intelligent educational server (Oi - ontologies)

Table 1. Partial classification of educational services

Service category	Learning	Assessment	References	Collaboration
Services	Course offering, integration of educational material, (creating lessons, merging contents from multiple sources, course sequencing), tutoring, presentation	On-line tests, performance tracking, grading	Browsing, search, libraries, repositories, portals	Group formation and matching, class monitoring

In Figure 4, pedagogical agents are external to the educational server. This may limit the pedagogical aspects of the provided services only to educational characteristics of the provided content. However, all the services provided by an educational server – including assessment and collaboration – should be affected by pedagogy. Hence an alternative approach is to include some pedagogical agents inside the architectural block of the educational server, as an intermediate interface between the requests and the services. These internal pedagogical agents may collaborate with the external ones to enable pedagogical support for all the services.

Web Mining and Social Networks

Web mining is the process of discovering potentially useful and previously unknown information and knowledge from Web data (Cooley et al., 1997). It encompasses tasks such as automatic resource discovery, automatic extraction and pre-processing of desired data from Web documents, discovery of common patterns across different Web sites, and validation and/or interpretation of discovered patterns (Chakrabarti et al., 1999). Figure 5 shows the most important categories of Web mining.

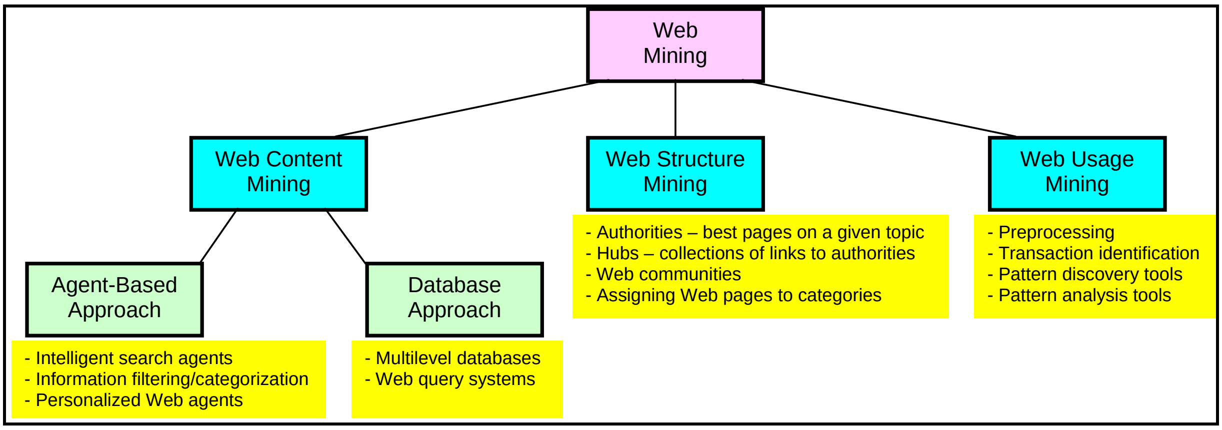

Figure 5. Web mining categories (after (Cooley et al., 1997) and (Chakrabarti et al., 1999))

All categories of Web mining are of interest for AIED. Personalized, ontology-enabled pedagogical agents can be deployed to continuously go *Web content mining* to collect globally distributed content and knowledge from the Web (large Web data repositories such as documents, logs, and services) and organize it into educational Web servers. The collected data can then be incorporated with locally operational knowledge/databases to provide a dedicated community of learners with centralized, adaptable, intelligent Web services. A pioneering work in this direction (albeit not directly related to Web services) is presented in (Trausan-Matu et al., 2002). The idea is that the knowledge the learners need to learn is not static but changes dynamically due to the continuous development and change of available resources on the Web, hence any sequencing of the learning material in a Web-based ITS should reflect that dynamics accordingly. Sticking to the hypothetical example of learning about Greek mythology from the previous section, consider what happens if an agent discovers some contents related to Zeus and previously unknown to the INES server. Using the ontology of Greek mythology, the agent will filter the new content and will categorize the relevant information as related to the concept of god and insert it correctly into a local database. The server itself may run some data mining over that database in order to discover relevant patterns among its contents (e.g., "The learner with such-and-such learning goal and such-and-such learner model, who was presented that other material about Zeus, should be presented the new one as well.") Likewise, the newly discovered content may be matched against the ontology and possibly used to improve the ontology through machine learning (see (Maedche and Staab, 2001) for further elaboration of ontology learning).

Further possibilities stem from deploying *Web structure mining* on the INES server side "in the background". The server can continuously mine the Web for refreshing the information in its database about the availability of external educational services, ranking the most authoritative Web pages and services on a given topic, or (re)organizing its local hub of links to such external pages and services. Moreover, such hubs are ontology supported and reflect not only the structure of related links, but also the hierarchy of related concepts and their instances (e.g., the hierarchical chain *deity-god-Zeus*). It is the relevant ontology that enables correct semantic assignment of Web pages and services, both already known and newly discovered, to a category in the hub. Reference services from the INES server can make direct dynamic use of such hubs, and collaboration services may start from the hubs to help the learner automatically discover peers on the Web who are interested in the same topic. This may result in creating and maintaining Web communities of human learners, but also in organizing and maintaining the related communities of pedagogical agents!

Probably the most attractive Web mining category for Web-based education is *Web usage mining*, which is related to discovering typical patterns of how the users browse, access, and invoke Web pages and services. All user activity is stored in log files on Web servers, hence such files represent a rich source of data for automatic pattern discovery using suitable data mining techniques. For example, suppose an INES server can select among several pedagogical strategies when conducting sessions with the learners. Through Web usage mining, it is possible to discover patterns about the learners' activities and the problems they encountered during the sessions and possibly relate them to the teaching strategies used. Also, patterns related to updating the student model, automatic service invocation, dynamic curriculum sequencing, and using various collaboration techniques can be also discovered in this way.

For Web-based AIED, the notion of *social networks* is essential. Social networks create a self-organizing structure of users (in our case – learners), information, and expert communities (authors, teachers, educational institutions) (Raghavan, 2002). Social relationships – such as friendship, co-working (co-learning, group formation), or exchanging information about common interests – connect these entities (Zhong et al., 2002). Such networks make a great basis for combining next-generation educational portals, ontologies, and search agents with functions such as Web mining, and knowledge management to create, discover, analyze, and manage the knowledge of different domains on the Web, presented in educational material.

Conclusions

The field of Web Intelligence creates a context for encompassing many different AIED efforts and sheds another light on both well-studied and emerging research and development problems in AIED (Devedžić, 2003). Of course, a trade-off exists between the positive effects of introducing ideas from another field into one's research directions and interests, and the effort needed to master the new ideas and practices. Still, there are a number of open WI issues and new research challenges – intelligent Web services, social networks, and Web mining, to name but a few – for AIED community to tackle and possibly incorporate into educational Web-based systems. Hence WI represents a very stimulating context for AIED research. It also enables *social-level WI* for AIED systems, since it encompasses issues central to social network intelligence, i.e. establishing social networks that contain communities of people, organizations, or other social entities – this is exactly the case of Web-based AIED systems.

The key advantages of applying WI techniques to AIED are enhanced adaptivity and enhanced learner comfort. WI enables course sequencing and material presentation not only according to the learner model, but also according to the most up-to-date relevant content from the Web. Automatic discovery, invocation, and composition of educational Web services can free the learner from many time-consuming activities that often disrupt the learning process itself. Finally, ontology-supported learning process greatly increases automation of a number of learners', teachers', and authors' activities related to Web-based learning environments.

True, a number of issues covered in the paper look as a wish list at the moment. For example, pedagogical agents are still not a common facility, neither are educational ontologies and services, hence educational servers are at best an experiment. Fortunately, this is highly likely to change in the foreseeable future. The reason is the fact that the enabling Web technologies are evolving rapidly. Moreover, it took just a couple of years to get from XML and XML Schema to much more abstract representational languages like OWL. With the advance of the upcoming, XML-based educational modeling languages (http://eml.ou.nl/forums/showthread.php?s=&threadid=60, http://www.e-learningcentre.co.uk/eclipse/vendors/modelling.htm), authors will be able to structure and organize educational material on the Web more easily, according to whatever formal or informal pedagogical model.

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What can the Semantic Web do for Adaptive Educational Hypermedia?

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Abstract
Semantic Web and Adaptive Hypermedia come from different backgrounds, but it turns out that actually, they can benefit from each other, and that their confluence can lead to synergistic effects. This encounter can influence several fields, among which an important one is Education. This paper presents an analysis of this encounter, first from a theoretical point of view, and then with the help of LAOS, an Adaptive Hypermedia (authoring) framework that has already taken many steps towards accomplishing the goals of the Semantic Web. Here we also show how the LAOS framework, and more specifically, its implementation, MOT (My Online Teacher), can be re-written in Semantic Web languages, as an exercise of bringing Adaptive Hypermedia and the Semantic Web closer together.

Keywords
Authoring of Adaptive Hypermedia, Adaptive Educational Hypermedia, XML, XML Schema, RDF, RDF Schema

Introduction

The Semantic Web (WC3) (http://www.w3.org/2001/sw/) can be said to be, from a constructivist point of view, all about authoring. That is manually or automatically labelling the pieces of information with semantically rich annotations which can be further interpreted automatically by agents or other (Web) programs. This interpretation – or reasoning – is done based on *Ontologies* (Mizoguchi, 2004).

Adaptive Hypermedia (AH) (Brusilovsky, 2001a) is the solution to the problem of personalization on the Web, especially for Educational Systems. *Adaptive Educational Hypermedia* (AEH) (Brusilovsky, 2001b) caters to the needs of each individual student, adapts to their *goals* (Clifford, 2000); *knowledge level* (De Bra, & Calvi, 1998); *background*; *interests* (Brusilovsky et al., 1996); *preferences* (Höök et al., 1997); *stereotypes* (Zakaria & Brailsford, 2002); *cognitive preferences* (Chen & Macredie, 2002) and *learning styles* (Stach et al., 2004).

What can the Semantic Web bring to adaptive hypermedia that AH doesn't already have? Nothing at a first glance, at least not with respect to the richness of adaptation available for each student. However as we shall see, this view changes if we talk about the scale of the adaptation; about the extent of information accessible for adaptation and about personalization between different systems.

The Semantic Web comes with new emerging standards based on evolving Web technologies, that allow the reuse of material in different contexts, flexible solutions, as well as robust and scalable handling.

Again, what does this bring to AH? It is true that traditional AH has been kept within a non-flexible framework working within given parameters for each system. Therefore, flexibility is one characteristic which AH can borrow from the Semantic Web. As we shall see, there are others.

Intelligence in AH was typically hidden within the delivery engine, and authoring tools worked with specific systems only. Recently however, authoring of Adaptive Hypermedia has moved towards generic authoring principles (Cristea & Mooij, 2003a), based on semantically labelled reusable material (*services*, as in Conlan et al.,2003; or *relationships*, as in AHA!, as described by De Bra et al., 2003a), even towards semantic labelling of behaviour (Cristea & Calvi, 2003).

The real solution comes, as previously hinted, from addressing the question of interoperability between different systems and interfacing. Previous experiments (e.g., Stewart et al., 2004) have shown that a "common language", a common denominator, is extremely important, so that the semantics can be preserved between different systems. It is at this level where the actual acceptance of standards by the different parties (authors, researchers, developers, end-users) becomes important, even if the standards might not fulfil *all* of their respective needs. Before we proceed, we have to analyse these needs in more detail.

The remainder of this document is structured as follows. First we look at Adaptive Hypermedia and the Semantic Web from the point of view of E-learning, to see if and how E-learning can benefit from them. The next section treats the adoption process of Semantic Web techniques and technologies by Adaptive Hypermedia. We then shortly sketch LAOS, an Adaptive Hypermedia (authoring) framework, along with its goals and connection to the Semantic Web. Then we consider LAOS from the point of view of Semantic Web languages, and attempt to express it in XML Schema paired with an example XML application. Next we describe MOT, an authoring system built based on LAOS. We look at some Semantic Web features of MOT, and we then express MOT in the Semantic Web language, RDF. Finally, we draw some conclusions.

E-Learning, Adaptive Hypermedia and the Semantic Web

Do the Semantic Web and Adaptive Hypermedia actually provide viable solutions for e-learning? Fensel &Musen (2001) call the Semantic Web a “bigger and more powerful” Web – but what can the Semantic Web do for e-learning? According to Brusilovsky (2001) “Adaptive Hypermedia is an alternative for the ‘one-size-fits-all’ approach in the development of hypermedia systems”. How does this benefit e-learning? As both Adaptive Hypermedia and Semantic Web have higher production costs than regular, linear hypermedia for e-learning, the benefits have to be evaluated carefully.

What are these benefits? Before embarking on one or the other solution, an educator or provider of "learning" (e.g., as a commodity) should consider the following questions:

1. *Do I only deal with learners of a given type* (as opposed to a variety of learners and learner characteristics)?
2. *Do I need to change (parts of) the content frequently or do I expect to perform changes in time to the given material* (as opposed to not at all)?
3. *Do I expect everything to be created by the same person, an expert who can deal with all aspects of a course (from contents to the adaptive behaviour, from notification type to other communication aspects, etc.),* as opposed to having different experts and roles for different parts of the authoring / creation process?
4. *Do I need to export (move data) between different learning systems,* as opposed to using only one system during the whole authoring and exploitation (learning material delivery) process?

Let’s look at the possible answers and treat the needs resulting from them one by one.

Learners of a given type

If the answer to the first question is yes, then adaptivity is most probably not the answer, and a one-size-fits-all approach is appropriate. There are some special cases in which learners of a given type still vary (for instance, in time) with respect to their needs, preferences, etc., but here we are considering a setting similar to that of educational TV broadcasting, without any type of personalization.

If the answer is no, and there are several types of learners, then Adaptive Educational Hypermedia is necessary, to cater for the different needs for each type of learner (for instance, for each stereotype, such as *beginner*, *intermediate*, *advanced*; or for each learning style expected, such as *field-dependent* and *field-independent*). The semantic web responds with user ontologies, but their actual applications still lie in the future.

Frequent content change

If the answer to the second question is yes, then the content has to be sufficiently malleable to be reused in different settings, so that each change can focus on the new issues and refine the old. Therefore, a layered approach with appropriate semantic labelling is necessary, at least with respect to the semantics inherent to the e-learning system used. The layers should reflect a higher level semantics, such as domain model, user characteristics, machine characteristics, etc. At a lower level, the semantics have to be applied all the way to the lowest level of reuse. So, for instance, if a paragraph can be reused, it should be appropriately labelled in order to be easily retrieved according to its semantics. Using semantic standards is of benefit in this case but not a necessity per se. Note that this semantic labelling is necessary even if the same person will be making the changes, in just the same way that programmers add comments to their code even if they will be the ones who will do the updates later.

If the answer to the second question is no, then there is no need to conform to standards or to any type of layered architecture. If one-time-creation is enough, and no changes are expected, then no special care has to be invested in order to semantically label the contents in any way.

Single author versus collaboration

If the answer to the third question is yes, then there is no particular need to do a grouping (and semantic labelling) of resources according to the role the user is playing. Indeed, most learning systems have only one role in mind, the learner. Even more popular are the systems targeting two roles: the author and the learner. For the latter, the author will be responsible for creation and production of everything the learner needs, in a perfect producer-consumer cycle. Adaptation may only be useful if the learners are of different types or if frequent changes occur (see previous questions), otherwise not. Similarly, added semantics, or standards, are not necessary for the simple systems described above.

However, if the answer is no, i.e., more authors are involved, doing the same or different tasks, or if more roles are involved, appropriate semantic labelling becomes crucial, and the use of internationally accepted semantic standards is beneficial for the scalability of people and roles involved.

For instance, the PROLEARN initiative (http://www.prolearn-project.org/), targeting mainly corporate e-Learning, has identified as many as five different roles in a generic learning system, given here with their description as proposed by several PROLEARN members:

- *learner*: A learner can be in different stages of his/her career, and thus also have slightly different needs. For instance, the learner can be a high school student with no idea about his/her future in terms of studies or career; a young professional that wants to find the best educational/business continuation opportunity; or a more experienced professional who turns into a new area and wants to strengthen his/her expertise in the area.
- *author*: The ultimate goal of any type of authoring of learning resources is to support, improve and trigger learning, except for the fact that they don't reflect the goals of a single learner, but those of a whole group of target learners. Authors are creators of Adaptive Learning Resources, but can have other tasks such as supporting synchronization, maintenance and usage in adaptive learning resources creation.
- *instructor*: An instructor is typically the only person directly communicating with the learner. This role can be considered as "a guide on the side" rather than "a sage on the stage". Activities that can be carried out by instructors include:
  - Providing additional guidance to learners
  - Providing recommendations to learners
  - Assessment of learners' work
  - Answering learners' questions
  - Monitoring discussion
  - Promoting discussion

There are similarities between the author role and the instructor role related to authoring of learning materials. If it is for specific use (just one session or learner), then it is the instructor role. If it will be reused, it becomes authoring.

- *manager*: The training manager is responsible for efficient and effective training of the employees. This role is usually found in the literature under different names, for example as the learning manager role. Training management within a company can be also seen as a sub-discipline of human resource management. Therefore, training managers are sometimes referred to as human resource managers or human resource developers. In smaller companies this role is frequently covered by one of the general managers. As training managers are responsible for the whole company, line managers, project managers or group managers usually take some of their tasks at lower levels, in the departments or project groups. Group managers for example oversee specific subject areas and are responsible for the knowledge evolution in those fields.
- *administrator*: Administrators' tasks are subdivided into user management, platform management and content management.

1. User managers have as tasks:
    a. Creation of an corporate user account
    b. Setting user rights
    c. Creating different types of users
2. Platform managers have as tasks:
    a. Setting new language for graphical user interface
    b. Managing the local settings
    c. Differentiating the visibility of the portal using themes
    d. Differentiating the portal main page
    e. Log management
3. Content managers have as tasks:
    a. Making the content invisible for all users or a set of users
    b. Learning modules management
    c. Defining resource types

The single author at the beginning of this section would have to unify the roles of PROLEARN author, instructor, manager and administrator.

In a more realistic setting, not only could these roles be taken by different persons, but there might be more than one person associated with each role. Therefore, in order to ensure *collaboration* and *cooperation* between the different roles and persons, both high-level are low-level semantics are vital. As Berners-Lee (2001) put it, the Semantic Web is "an extension of the current one, in which information is given well-defined meaning, better enabling computers and people to work in cooperation".

From the point of view of adaptivity and Adaptive (Educational) Hypermedia, more roles can mean also a need for adaptation of each role separately.

Exporting between systems

The major case for semantic labelling is given by the answer of yes to the fourth question. Prior research and implementation of exporting and conversion between *adaptive (educational) hypermedia authoring and adaptive (educational) hypermedia delivery systems* (MOT to WHURLE; in Stewart et al., 2004, MOT to AHA!; in Stach et al., 2004 and Cristea et al., 2003, Interbook to AHA!; in De Bra et al., 2003b, AHA! to Claroline; in Arteaga et al., 2004) has shown that the most important step is the agreement on a common platform of semantics between the systems. This means that educational material with a given pedagogical structure created in one system can be delivered by another, while maintaining both the contents and the pedagogic semantics. On a peer-to-peer basis, such conversions can be done using local semantics without explicit connection to the Semantic Web standards. However, if these conversions have to be done on a larger scale, with arbitrary systems – such as considered for the PROLEARN portal – alignment to internationally accepted standards will become a necessity.

According to Schwartz, 2003, the Semantic Web "is meant to enable an environment in which independent, Internet-connected information systems can exchange knowledge and action specifications". This means for the field of e-learning easy exchange and export of data and resources for e-learning.

If the answer is no, than, other, cheaper means will suffice – instead of the more time & energy consuming semantic annotation.

The Semantic Web Stack and Adaptive Hypermedia

The Semantic Web stack (Figure 1) has been proposed and gradually refined by Berners-Lee, 2003, and is supposed to guide us through the process of increasing level of semantics, as well as be always updated with the new corresponding web technologies.

The basis of semantics are resources, identified via their unique resource identifier (URI) or internationalized resource identifier (IRI). The next semantic layer is the XML, a set of syntax rules for "creating semantically rich markup languages in a particular domain" (Daconta et al., 2003) together with its namespaces ("a simple mechanism for creating globally unique names for the elements and attributes of the markup language", to avoid vocabulary conflicts). On top of XML is the resource description framework, RDF, simply put, an XML language to describe whole resources (as opposed to only parts of them, as with XML). RDF Schema is a language that enables the creation of RDF vocabularies; RDF Schema is based on an object-oriented approach.

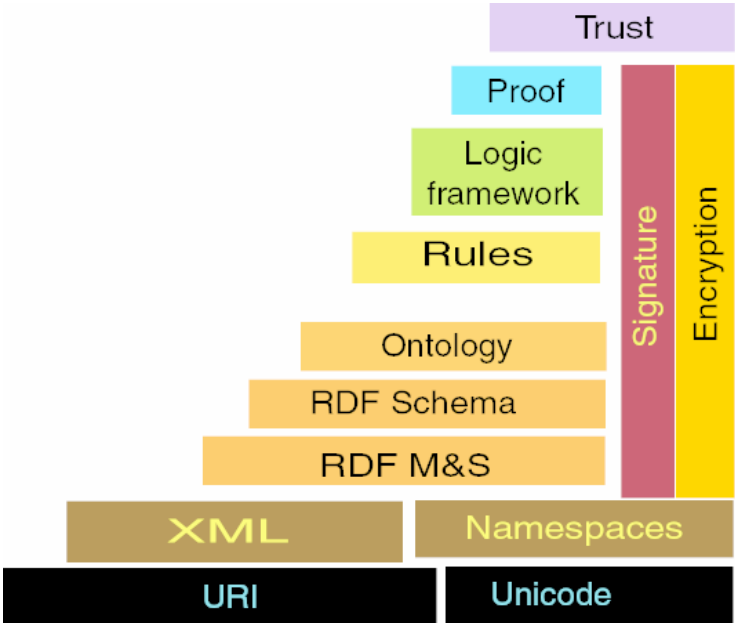

Figure 1. The Semantic Web stack (Berners-Lee, 2003)

Semantics increases from the lower levels towards the top of the stack. Ontologies are constructed from structured vocabularies and their meanings, together with explicit, expressive and well-defined semantics. In particular, ontologies make knowledge reusable by featuring *classes* (general things), *instances* (particular things), *relationships* between those things, *properties* for those things (with their values), *functions* involving those things and *constraints* on and rules involving those things. *Ontologies* have their own spectrum of increasing semantics, as described in Figure 2 (Daconta et al., 2003).

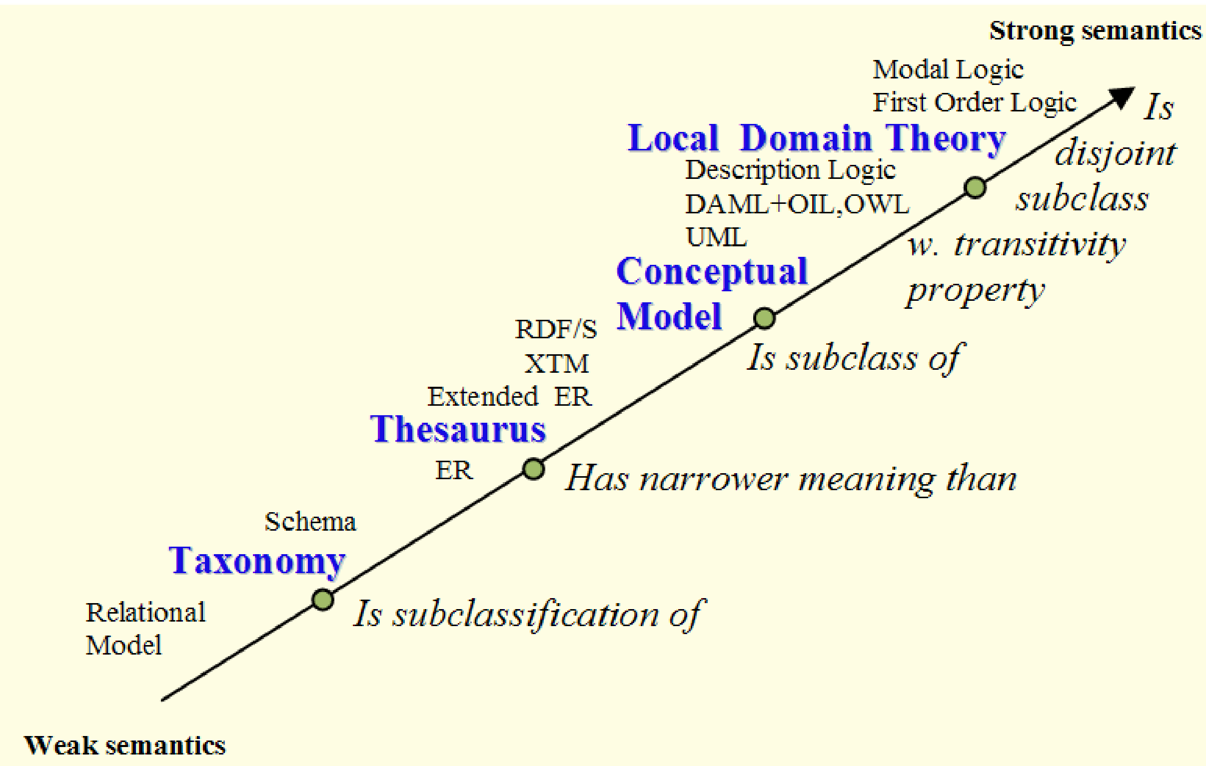

Figure 2. The Ontology Spectrum (Daconta et al., 2003)

Taxonomies contain structured data, where the semantics of the relationship between a parent and a child node is not well specified (can be *subclass of* or *part of*). *Thesauri* are controlled vocabularies, with clearly defined equivalence, homographic (spelled the same way), hierarchical and associative relationships (e.g., WordNet http://www.cogsci.princeton.edu/~wn/). A *conceptual model* permits class-subclass hierarchies (as in UML). *Logical local domain theories* are directly interpretable semantically by the software, and represent the highest aspiration for ontologies.

As Dumbill, (2001) notes, speaking of an earlier version, "we should be careful not to restrict Semantic Web technologies to just those explicit layers in Berners-Lee's idealized diagram. There's obviously a difference between what is on the Web, and what is in the diagram (HTML is not mentioned, for instance).". This is still true today, especially as the upper layers have not been nailed-down to a specific technology – although OWL (http://www.w3.org/2004/OWL/) is supposed to become the new WWW and Semantic Web-compatible ontology language (replacing DAML+OIL, McGuiness et al., 2002).

If we compare the latest Semantic Web stack with the Adaptive Hypermedia systems currently available, many AH systems don't make it even to the second level (*XML*), although all of them use higher level representations, such as *Rules* and sometimes a *Logic framework*. The main difference is not the representation level used, but the manner of its expression: first order logics (*FOL*) are often used, (loosely) coupled with *If-Then* rules or *Condition-Action* rules (e.g., Wu, 2002). However, the rules and the resources are often described together (De Bra et al., 2003a) or are mixed together with other functionalities of the delivery system. In the latter case, reuse is not possible.

None of the Adaptive Hypermedia systems actually goes up the scale in Figure 1 as far as *Proof*, and, as has been noted by Wu (2002), *termination* and *confluence* cannot be guaranteed for the general case in most AH systems. They usually require careful authoring by specialists aware of the possible pitfalls and loops.

However, we note in recent years more interest in XML and XML-based languages within the AH community, and systems such as AHA! (De Bra & Calvi, 1998), WHURLE (Moore et al., 2001) share this common base with the Semantic Web stack.

Adaptive Hypermedia attempts higher up the stack, with *RDF* and *RDF schema* representations have been done, e.g., in Personal Reader (Dolog et al., 2003), in GEAHS (Jacquiot et al., 2004), in Hera (Frasincar et al., 2003) and even *OWL* and RDF in DLRS (Maneewatthana et al., 2004).

LAOS: The Adaptive Hypermedia framework

The LAOS (Layered AHS Authoring-Model and Operators) model (Figure 3), introduced in Cristea & de Mooij (2003a), is a generalized model for *generic, dynamic Adaptive Hypermedia (authoring)*, based on the AHAM model (Wu, 2002). The model consists of five layers:

- *domain model* (DM):containing a collection of linked (learning or other) resources
- goal and constraints model (GM): containing goal-related information, such as instructional and pedagogic information about the resources
- *user model* (UM): containing user-related information, such as information about the learner
- *adaptation model* (AM): containing the behaviour and dynamics, such as, a learning style related adaptive strategy (Cristea, 2004)
- *presentation model* (PM): containing display and machine-related information, such as the foreground-background colour scheme for the course presentation.

LAOS was built on the idea of the separation of concerns, and therefore advocates the separation of information from the authoring perspective, as well as from the storage point of view. The main goals (or 'credo') of the LAOS model are as follows:

- *Flexibility*: seen as the semantically meaningful different combinations that can be generated by automatically populating the different layers of the LAOS model, based on previous ones. This automatic processing can only be done if the data in the original layers is semantically well-labelled. Semantically meaningful data and links can be then interpreted to generate new ones (Cristea, 2003).
- *Expressivity*: the semantics of the elements of the model should be machine understandable, for one thing, and also easy to grasp for humans (so that a course author, for instance, can understand what data and meta-data he is creating).
- *Reusability*: to enable reuse of all aspects of the adaptive (educational) hypermedia.

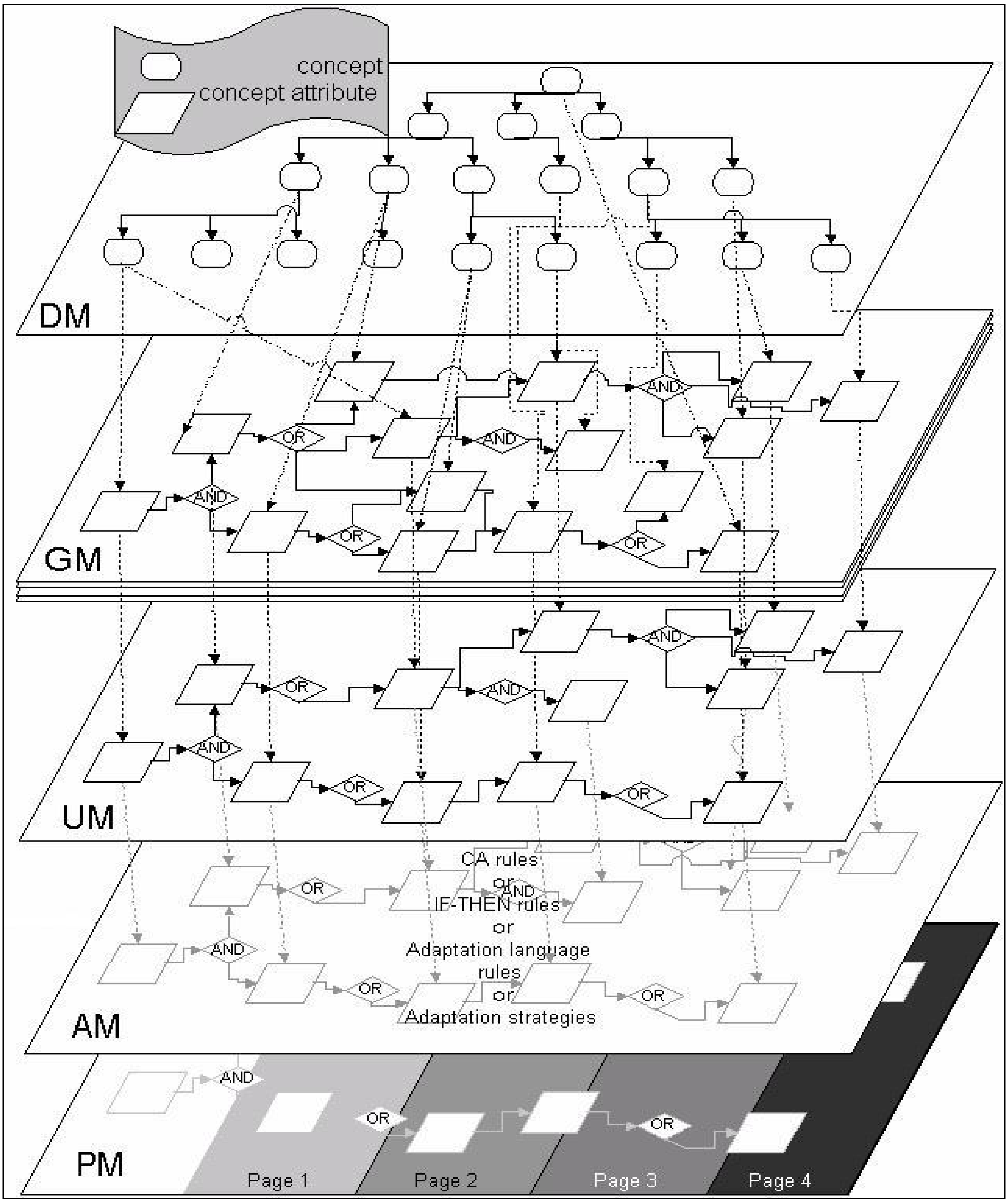

Figure 3. The LAOS model (Cristea & De Mooij, 2003a)

- *Non-redundancy*: to avoid creation of the same element of an AEH more than one time, in, for instance, a different context. This is essential, as most current AH systems would force you to define the same concept (such as a piece of courseware) twice, if it is used in a different context.
- *Cooperation*: to allow the collaboration and cooperation of different authors, either synchronously, during the authoring process, or, more often, consecutively, during the building and refinement steps of, for instance, a courseware unit. Moreover, cooperation means that separation of concerns is applicable also for the authors, and task-specialized authors can be involved (such as domain specialists, adaptation specialists, pedagogy specialists, etc.).
- *Inter-operability*: the framework should be generic enough, so that authoring of Adaptive Educational Hypermedia based on these principles could be easily converted into material for different AEH delivery platforms.

- *Standardization*: the framework should describe and extract patterns at the different levels of granularity, starting with the above five layers and detailing each layer separately; these patterns should be able to feedback into extant standards and provide information for enriching them according to the needs of adaptivity and pedagogy.

As can be seen, these goals are overlapping with the goals of the Semantic Web. Indeed, the Semantic Web requires the following:

- *Flexibility*: metadata for the Semantic Web, or structured data about data, should improve discovery of and access to such information (Signore, 2003, W3C), thus leading to flexible reuse and re-construction of the initial material in different contexts.
- *Expressivity*: the Semantic Web is giving meaning, in a manner understandable by machines, to the content of documents on the Web (WordfQ, Semantic Web definition)
- *Reusability*: the Semantic Web targets knowledge sharing (Signore, 2003, W3C)
- Non-redundancy: this is not a Semantic Web requirement as such; however, reuse on the Semantic Web implies that the content will not have to be regenerated, but just put in a different context.
- *Cooperation*: the Semantic Web targets collaborative development (Miller, 2003, W3C)
- *Inter-operability*: the Semantic Web aims at common metadata vocabularies (WordfQ, Semantic Web definition); and at "Leading the Web to its Full Potential..." "...by developing common protocols that promote its evolution and ensure its interoperability." (Miller, 2003, W3C); interoperability should be both technical and semantic (Signore, 2003, W3C)
- *Standardization*: in order to have inter-operability, the Semantic Web is constantly developing new standards for web languages and technologies.

Another goal of the Semantic Web is to make the Web accessible to all by promoting technologies that take into account the vast differences in culture, languages, education, ability, material resources, and physical limitations of users on all continents (Signore, 2003, W3C). This goal is shared with the self-evident goal of Adaptive Hypermedia, which is catering for the different, personal needs of its users.

The layered design of LAOS, based on separation of concerns, also matches the request for modularity in the design principles for the web outlined by the Semantic Web (Signore, 2003, W3C).

It should be no wonder, therefore, that the result is Semantic Web compatible. In order to confirm this, in the following sections we shall express the LAOS model and its implementation, MOT, in standard Semantic Web languages, such as XML, XML Schema and RDF.

LAOS for the Semantic Web

Previously (Cristea & De Mooij, 2003a) we have expressed LAOS in terms of structure and functionality, and more recently, in terms of a list of basic definitions (Cristea, in press). Here we will only repeat the definitions that we convert directly, for the purpose of readability.

In order to verify the compatibility of LAOS with the Semantic Web, let us have a look at how we are able to express LAOS in terms of the Semantic Web languages. In the following, we are going to give some extracts of an XML Schema for LAOS.

As said previously, LAOS is built of five layers. Figure 4 shows an extract of the XML Schema of the LAOS model, listing these five layers.

Please note that the LAOS model can contain an unbounded (aka, unlimited) number of maps for each layer type. This means, for instance, that several *domain maps* corresponding to several books can be described within this model.

Similarly, different pedagogic goals will result in transforming the same domain map, for instance, into many different *goal and constraints maps*. Obviously, more than one user (or learner) can be defined with this model.

Note that, although individual *user maps* can also be defined with LAOS, the idea is to define either stereotypes, or groups of users, so that the same basic model can be reused. Of course, during the actual interaction of, for instance, a student, with the delivery system, this basic model will get updated and will generate several individual versions. This can happen, e.g., if all students are beginners, but some have been studying more than others, and therefore accessed more pages or passed more tests. Their knowledge level will be accordingly updated by the delivery system and will be different for each user, although they all belong to the same basic category, beginner.

```
<xsd:element name= "modelLAOS" >
 <xsd:complexType>
  <xsd:sequence>
   <xsd:element name = "domainMap"  type = "mns:domainMap"
                                  minOccurs= "0"   maxOccurs= "unbounded" />
   <xsd:element name= "goalAndConstraintsMap"  type = "mns:goalAndConstraintsMap"
                                  minOccurs= "0"   maxOccurs= "unbounded" />
   <xsd:element name= "userMap"  type= "mns:userMap"
                                  minOccurs= "0"   maxOccurs= "unbounded" />
   <xsd:element name= "presentationMap"  type= "mns:presentationMap"
                                  minOccurs= "0"   maxOccurs= "unbounded" />
   <xsd:element name= "adaptationStrategy"  type= "mns:adaptationStrategy"
                                  minOccurs= "0"   maxOccurs= "unbounded" />
  </xsd:sequence>
 </xsd:complexType>
</xsd:element>
```

Figure 4. LAOS XML Schema extract: the LAOS model

Furthermore, different *presentation maps* can be defined, giving the parameters, for instance, for a desktop presentation, or a palmtop presentation.

Finally, the material stored can be presented according to one or more *adaptation strategies* that can correspond to instructional strategies. For instance, an instructional strategy for the learning style ‘field-dependent’ (Stach et al., 2004) can be implemented by preferentially displaying the concepts at the same depth of the conceptual tree of either a goal and constraints map or domain map.

Also note that the XML schema elements of the LAOS model in Figure 4, such as ‘domainMap’, ‘goalAnd ConstraintsMap’, ‘userMap’, ‘presentationMap’ and ‘adaptationStrategy’ are defined as being of a type of the same name, which still has to be defined (e.g., element named ‘domainMap’ is of type ‘domainMap’ in a namespace ‘mns’).

In Cristea, (in press) we defined a domain map as follows:

A **domain map** DM of the AH system is determined by the tuple <*C*, *L*, *Att*>; where *C* a set of concepts; *L* a set of links and *Att* a set of DM attributes.

Let’s see how the respective ‘domainMap’ type will look in XML Schema. Figure 5 shows the definition of the XML schema type ‘domainMap’, as composed of two elements, concept map information and a root element of the hierarchy of concepts. This hierarchy of concepts is further detailed in Figure 6, where the type ‘complexDomainConcept’ is detailed as being composed of a current concept, and an unbounded list of sub-concepts. The hierarchy corresponds to (an instance of) the set of links *L* in our former definition. There are different links that can appear in a domain map, beside the hierarchic ones, but we are not going into details in the current paper. The concepts in the hierarchy correspond to the set of concepts, *C*. The concept map information, defined as the type ‘conceptMapInfo’ in Figure 7 lists the attributes that describe the concept map. These correspond to *Att*, the set of domain model attributes.

```
<xsd:complexType name="domainMap">
 <xsd:sequence>
  <xsd:element name="conceptMapInfo" type="mns:conceptMapInfo"
                                minOccurs="1" maxOccurs="1"/>
  <xsd:element name="rootElement" type="mns:complexDomainConcept"
                                minOccurs="0" maxOccurs="1"/>
 </xsd:sequence>
</xsd:complexType>
```

Figure 5. LAOS XML Schema extract: the domain map

In Cristea, (in press) we defined a domain concept as follows:

A **domain concept** $c \in DM_i.C$ is defined by the tuple $<A, C>$; where $A \neq \emptyset$ is a set of domain map attributes; C a set of domain map sub-concepts; DM_i the domain map instance the concept belongs to.

Figure 6 defines, as said, the 'complexDomainConcept' consisting of a main part, the 'domainConcept', and an unbounded set of sub-concepts; the type 'domainConcept' consists of some general concept information (not given here due to lack of space) and an unbounded set of extra attributes (element 'extraAttribute').

```
<xsd:complexType name="complexDomainConcept">
 <xsd:sequence>
  <xsd:element name="domainConcept" type="mns:domainConcept"
                                       minOccurs="1" maxOccurs="1"/>
  <!-- list of sub-concepts -->
  <xsd:element name="subConcept" type="mns:complexDomainConcept"
                                       minOccurs="0" maxOccurs="unbounded"/>
 </xsd:sequence>
</xsd:complexType>
<xsd:complexType name="domainConcept">
 <xsd:sequence>
   <xsd:element name="conceptInfo" type="mns:conceptInfo"
                                       minOccurs="1" maxOccurs="1"/>
              ...
   <xsd:element name="extraAttribute" type="mns:extraAttribute"
                                       minOccurs="0" maxOccurs="unbounded"/>
 </xsd:sequence>
</xsd:complexType>
```

Figure 6. LAOS XML Schema extract: the domain concept

```
<xsd:complexType name="conceptMapInfo">
 <xsd:sequence>
  <xsd:element name="description" type="xsd:string" minOccurs="0" maxOccurs="1"/>
  <xsd:element name="owner" type="mns:author" minOccurs="1" maxOccurs="1"/>
 </xsd:sequence>
 <xsd:attribute name="id" type="xsd:nonNegativeInteger" use="required"/>
 <xsd:attribute name="title" type="xsd:string"/>
 <xsd:attribute name="creationDate" type="xsd:date" use="required"/>
 <xsd:attribute name="modificationDate" type="xsd:date"/>
</xsd:complexType>
```

Figure 7. LAOS XML Schema extract: the concept map information

To see how an actual instance of a domain map will look when we use the XML Schema defined above, see Figure 8. The figure shows an actual instance with completed attributes, such as the attribute 'introduction', and 'text' of a concept on "Neural Networks". The content displayed is kept short for visibility.

To examine now the other elements in Figure 4, we look at the definition of a goal and constraints map (Cristea, in press):

A **goal and constraints map** GM of the AH system is a tuple $<G, GL, GAtt>$; G represents a set of goal and constraints concepts; GL a set of goal and constraints links and $GAtt$ is a set of goal and constraints attributes.

The XML Schema definition of 'goalAndConstraintsMap' is similar to that of the 'domainMap' in Figure 5, and the general information on it is identical to that in Figure 7, and will therefore not be discussed any further.
With this the mapping from the original definition to the XML Schema is accomplished. Instead, Figure 9 shows the main difference that appears.

In Cristea (in press), we defined:

A **goal and constraints concept** g is defined by the tuple $<GA, G, DM_j.c.a>$; $GA \neq \emptyset$ is a set of attributes; G a set of sub-concepts; $DM_j.c \in C$ is the ancestor domain map concept and $DM_j.c.a \in A$ is an attribute of that concept.

with the following restriction:

Constraint. Each goal and constraints concept g must be involved in at least one special link gl, called **prerequisite link** (link to ancestor concept). Exception: root concept.

```
<?xml version="1.0" encoding="UTF-8"?>
<domainConcept        xmlns="http://wwwis.win.tue.nl/~acristea/LAOS/markup/LAOS-Schema-
XMLSchema"                        xmlns:xsd="http://www.w3.org/2001/XMLSchema-instance"
xsd:schemaLocation="http://wwwis.win.tue.nl/~acristea/LAOS/markup/LAOS-Schema-
XMLSchema LAOS-Schema-XMLSchema.xsd" >
 <domainConcept>
  <conceptInfo id="3" creationDate="2003-09-24" title="Neural Networks" >
        <owner id="15" name="Alexandra I. Cristea" />
  </conceptInfo>
  <introduction>
        This is an introduction to Neural networks.
  </introduction>
  <text>
  Neural Networks are based on biological Neural Networks in the brain of the human
(or other living beings for that matter).
  </text>
  <conclusion> This section gives you a very short
  overview on Neural Networks. You should be able to distinguish between ANN and BNN.
  </conclusion>
 </domainConcept>
</domainConcept>
```

Figure 8. LAOS XML Instance extract: an example domain concept map

Figure 9 defines the type ‘goalAndConstraintsConcept’, with, as is expected, concept information as in Figure 7 and extra attributes, corresponding to the set of attributes in the ‘goal and constraints concept’ definition above. The constraint of the prerequisite link is given by the concept hierarchy, which is not repeated, as it is similar to that of domain concepts. Moreover, the ‘order’ element in the XML schema in Figure 9 can decide the order in which the concepts can appear.

```
<xsd:complexType name="goalAndConstraintsConcept">
 <xsd:sequence>
  <xsd:element name="conceptInfo" type="mns:conceptInfo"
                                      minOccurs="1" maxOccurs="1"/>
  <xsd:element name="extraAttribute" type="mns:extraAttribute"
                                      minOccurs="0" maxOccurs="unbounded"/>
 </xsd:sequence>
 <xsd:attribute name="order" type="xsd:nonNegativeInteger"/>
 <xsd:attribute name="weight" type="xsd:nonNegativeInteger"/>
 <xsd:attribute name="label" type="xsd:string"/>
 <xsd:attribute name="domainConceptId" type="xsd:nonNegativeInteger"/>
 <!-- the concept it refers to; only one -->
 <xsd:attribute name="domainAttributeName" type="xsd:string"/>
 <!-- the attribute within the concept  it refers to; only one -->
</xsd:complexType>
```

Figure 9. LAOS XML Schema extract: the goal and constraints map

An example of a partially filled-in goal and constraints concept map, with hierarchy and attributes, is displayed in Figure 10. For readability, header, schema location and namespace information are omitted.

The figure shows a goal and constraints concept map created based on the domain map with concepts such as in Figure 8. It contains one root concept with the title "Neural Networks Intro Text", corresponding to the domain concept with Id=3 (as in Figure 8), and two sub-concepts: "Biological Neuron Intro Text" and "Artificial Neuron Intro Text" (based on domain concept with Id=5 and Id=9, respectively).

```
<goalAndConstraintsMap>
 <conceptMapInfo id="30" title="Neural Networks for beginners"
               creationDate="2003-09-25" modificationDate="2004-07-05">
        <description>This is a lesson map on the topic of Neural Networks, for
               beginners.</description>
        <owner id="15" name="Alexandra I. Cristea"/>
 </conceptMapInfo>
 <rootElement>
   <goalAndConstraintsConcept weight="30" label="beginner" domainConceptId="3"
               domainAttributeName="text">
        <conceptInfo id="14" creationDate="2003-09-25"
               title="Neural Networks Intro Text">
            <owner id="15" name="Alexandra I. Cristea"/>
        </conceptInfo>
   </goalAndConstraintsConcept>
   <subConcept>
      <goalAndConstraintsConcept weight="30" label="beginner" domainConceptId="5"
               domainAttributeName="text">
         <conceptInfo id="32" creationDate="2003-09-25"
               title="Biological Neuron Intro Text">
             <owner id="15" name="Alexandra I. Cristea"/>
         </conceptInfo>
      </goalAndConstraintsConcept>
   </subConcept>
   <subConcept>
      <goalAndConstraintsConcept weight="30" label="beginner" domainConceptId="9"
               domainAttributeName="text">
         <conceptInfo id="22" creationDate="2003-09-25"
               title="Artificial Neuron Intro Text">
             <owner id="23" name="Alexandra I. Cristea"/>
          </conceptInfo>
      </goalAndConstraintsConcept>
    </subConcept>
  </rootElement>
</goalAndConstraintsMap>
```
Figure 10. LAOS XML Instance extract: an example goal and constraints map

The presentation map is very similar in structure, with the only difference that the attributes in it reflect machine characteristics; hence this will not be discussed any further.

Figure 11 shows the XML schema extract of the user map. Here we are using an extended definition based on the one in Cristea (in press), as follows:

A **user concept** *u* is defined by the tuple $<AU, U, \mathrm{GM_i}.(g.(a))/\ \mathrm{DM_i}.(c.(a))>$; $AU \neq \emptyset$ is a set of user model attributes; *U* a set of UM sub-concepts; $\mathrm{GM_i}.(g.(a))/\ \mathrm{DM_i}.(c.(a)) \in G/C$ is the ancestor goal and constraints map (or domain map) (concept or concept attribute).

This definition describes in a very compact form the fact that user model attributes can be layered over different types of maps – such as domain maps or concept maps. Moreover, it expresses the fact that user model attributes can be overlaid within these maps at different levels - such as at the level of the whole map, or at the level of a concept, or finally, at the level of an attribute.

To explain why we need all these different overlay levels, let's look at a simple example. We have the goal and constraints map in Figure 10, and we try to express the knowledge of the user regarding this map. We can say the user's global knowledge is 70%, or we can detail it and say that the knowledge corresponding to goal and constraints concept with id= "14" is 70%, that of id= "32" is 60% and that of id= "22" is 80%. In a domain concept map such as the one depicted in Figure 8, we can go below the level of the concept with id= "3" and talk about the knowledge corresponding to the attribute "text", or the attribute "introduction", etc. Therefore, in order to allow user map attributes such as 'knowledge' to be refined and attributed to the different parts of the content, we need to define different levels of overlay.

The XML Schema in Figure 11 implements this idea, by allowing three layers of overlay for the domain model. If the goal and constraints map is not adding extra attributes (as defined up to now in the XML Schema extracts), then an overlay at the map level is enough. This is due to the fact that the goal and constraints concepts correspond to domain map concept attributes.

```
<xsd:complexType name="userMap">
  <xsd:sequence>
    <xsd:element name="conceptMapInfo" type="mns:conceptMapInfo"
                minOccurs="1" maxOccurs="1"/>
    <xsd:element name="userDescription" type="mns:userDescription"
                minOccurs="0" maxOccurs="1"/>
     <xsd:element name="userConceptOverlayDomainMaps"
                type="mns:userConceptOverlayDomainMaps" minOccurs="0"
                maxOccurs="unbounded"/>
     <xsd:element name="userConceptOverlayGoalAndConstraintsMaps"
                type="mns:userConceptOverlayGoalAndConstraintsMaps"
                minOccurs="0" maxOccurs="unbounded"/>
     <xsd:element name="userConceptOverlayDomainConcepts"
                type="mns:userConceptOverlayDomainConcepts"
                minOccurs="0" maxOccurs="unbounded"/>
     <xsd:element name="userConceptOverlayDomainAttributes"
                type="mns:userConceptOverlayDomainAttributes"
                minOccurs="0" maxOccurs="unbounded"/>
  </xsd:sequence>
```

Figure 11. LAOS XML Schema extract: the user map

The actual definition of these overlay types is not discussed, due to lack of space.

The last, but quite different type definition refers to the adaptation strategy. Adaptation strategies represent the only dynamic part of the LAOS model. They are the ones instructing the delivery engine about how to handle the static data generated by the other layers. Figure 12 shows the XML Schema for the LAOS adaptation strategies. Beside having the ‘conceptMapInfo’, just like all the other concept maps previously shown, an adaptation strategy looks very much like a program, listed as the element ‘strategyText’ in Figures 12 & 13. However, the programming language is restricted to the *adaptation language* as defined in (Cristea & Calvi, 2003). Other elements of the strategy are its ‘inputVariables’, such which concept maps are used; ‘usedLanguageConstructs’, with the sub-list of adaptation language constructs used and ‘usedProcedures’, the author-defined extensions to the adaptation language.

```
<xsd:complexType name="adaptationStrategy">
  <xsd:sequence>
   <xsd:element name="conceptMapInfo" type="mns:conceptMapInfo"
                       minOccurs="1" maxOccurs="1"/>
   <xsd:element name="inputVariables" type="xsd:string"
                       minOccurs="0" maxOccurs="unbounded"/>
   <xsd:element name="usedLanguageConstructs" type="xsd:string"
                       minOccurs="1" maxOccurs="unbounded"/>
   <xsd:element name="usedProcedures" type="mns:adaptationProcedure"
                       minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="strategyText" type="xsd:string"
                       minOccurs="1" maxOccurs="1"/>
  </xsd:sequence>
</xsd:complexType>
```

Figure 12. LAOS XML Schema extract: the adaptation strategy

Figure 13 shows a short instance populating the schema in Figure 12. The strategy only determines that if the user is a beginner, he should see the lesson ‘Neural Networks for beginners’. Other, more complex strategy implementations have been discussed elsewhere (Cristea, 2004) and are not further detailed here.

```
<adaptationStrategy>
  <conceptMapInfo id="50" title="Neural Networks for beginners"
       creationDate="2003-09-25" modificationDate="2004-07-05">
   <description>This is an adaptation strategy for beginners.</description>
   <owner id="15" name="Alexandra I. Cristea"/>
  </conceptMapInfo>
  <usedLanguageConstructs> if </usedLanguageConstructs>
  <strategyText>
       if UM.concept.stereotype == beginners
       then Neural Networks for beginners.concept.show = TRUE
  </strategyText>
</adaptationStrategy>
```

Figure 13. LAOS XML instance extract: an example adaptation strategy

MOT: The adaptive (educational) hypermedia authoring system

MOT (My Online Teacher) is an Adaptive Educational Hypermedia authoring system developed based on the LAOS framework. At the time of the writing, MOT implements:

- the domain model, as a *conceptual domain model* for courses (Cristea & De Mooij, 2003b),
- the goal and constraints model, as a *lesson model*, (Cristea & De Mooij, 2003b)
- the user model, as a first version of a hybrid model (in idea similar to Zakaria & Brailsford, 2002) featuring both *stereotypes* and *overlay user model*, as well as personal information, interests, etc.
- the adaptation model, in the form of an (instructional) *adaptive strategy* (Cristea, 2004) creation tool, based on an *adaptive language* (Cristea & Calvi, 2003) that uses as an intermediate representation level of LAG (Layers of Adaptive Granulation) grammar (Cristea & Verschoor, 2004)
- the presentation model is currently being implemented, in the form of a hybrid model, similar to the user model.

MOT conforms to the LAOS principles, using a concept-oriented approach. This means that the information about a course, for instance, is stored in MOT in the form of linked domain concepts, expressed by their attributes, as we have previously seen in the LAOS description.

MOT features some recommended, standard attributes, some of which have been shown in Figure 8: *title, keywords, pattern, introduction, text, explanation, conclusion* and *exercise*. The combination of these given attributes and the keywords used to describe concepts can lead to automatic discovery of *relatedness links* “and hence to improve the consistency and breadth of linking of WWW documents at retrieval time (as readers browse the documents) and authoring time (as authors create the documents)”, as in COHSE (Carr et al., 2001).

As ontological reasoning is based on rich semantic annotation & labelling (Schwarz, 2003), the labelling in MOT, together with the layered structure inherited from LAOS, creates a basis for ontological processing. Therefore, some reasoning within MOT is possible. This is reflected at the level of the adaptation model, where adaptation strategies can be designed not only at instance, *specific* level (such as in writing a rule about the piece of material called “Neural Networks for beginners”), but also at a *generic* level (such as a rule specifying to show all material labelled “introduction” in the current lesson).

MOT for the Semantic Web

MOT is written in Perl and its data structures are stored in MySQL, in order to be both flexible and easy to export. As has been shown previously, this format allows MOT to interface with different delivery systems, such as AHA! (Stach et al., 2004) and WHURLE (Stewart et al., 2004).

In the following, we will look at and comment upon an exercise to express MOT in the Semantic Web language RDF.

Figure 14 shows extracts of the RDF Schema of MOT and Figure 15 shows an RDF instance of MOT, for the *Domain Map* and the *Goal and Constraints Map*. The figures also reflect the connection between the Domain Map and the Goal and Constraints Map, conform with the LAOS goal of non-redundancy: the information from the Domain Map is filtered and restructured in the Goal and Constraints Map in order to be more appropriate for the actual presentation, but is not copied, just referred to (via pointers). For both figures, the left-hand side represents the Domain Model, and the right-hand side the Goal and Constraints Model. The upper side is the author information. Let's look first at Figure 14.

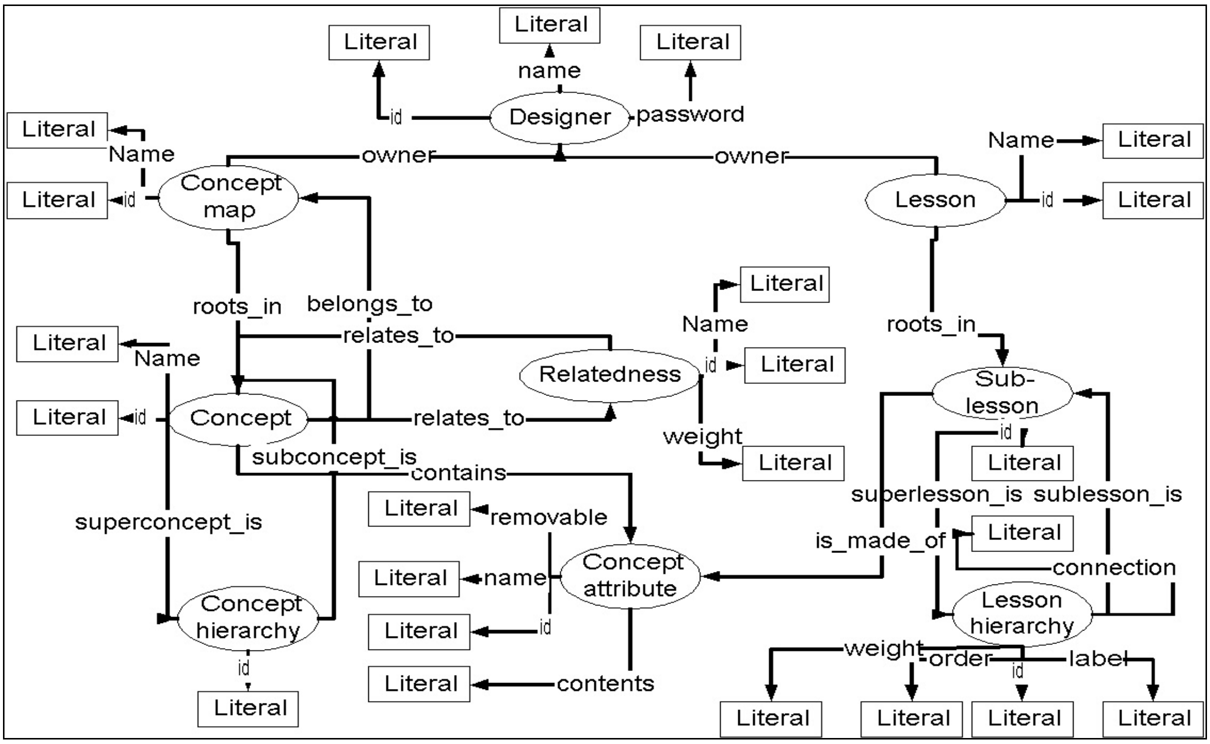

Figure 14. RDF Schema of two MOT layers (Cristea & De Mooij, 2003a).

A MOT domain '*concept map*' couples the '*name*' of a '*designer*' to a hierarchy of concepts. It contains a pointer to the root of this concept hierarchy. The structure of this hierarchy is stored in several '*concept hierarchy*' objects, as follows.

A MOT domain concept contains one or more sub-concepts, which are concepts in their turn, hence inducing a hierarchic (tree) structure of concepts ('*superconcept_is*', '*subconcept_is*'). The hierarchical structure of concepts is implemented by means of a separate '*concept-hierarchy*' entity, relating a super-concept to one or more sub-concepts.

Each domain concept '*contains*' domain attributes. These attributes hold pieces of information about the concept they belong to. There are several kinds of attributes possible, corresponding to the different attribute instances in the diagram. For example, a concept can have a '*title*'-attribute, a '*description*'-attribute or an '*example*'-attribute.

Domain attributes can be related to each other. Such a *relatedness link* (as previously discussed), is characterized by a '*label*' and a '*weight*', and indicates that their contents treat similar topics. A relatedness-relation is also given a type, indicating by which attribute(s) the concepts are related. This type is one of the possible attribute types (for example '*title*', if the concepts are related by their titles).

In MOT, the goal and constraints map is expressed as a '*lesson*' map. A lesson couples the '*name*' of a '*designer*' to a hierarchy of sub-lessons. It contains a pointer to the root of the sub-lesson hierarchy, which consists of sub-lessons which are related by means of '*lesson hierarchy*' objects, comparable to the '*concept hierarchy*' objects in the concept domain.

Sub-lessons within a lesson can be OR-connected (therefore becoming lesson alternatives, from which the appropriate one will be selected according to user map variable settings) or AND-connected (meaning that a student has to study all sub-lessons, regardless). To facilitate this, a lesson contains a lesson attribute, which in its turn contains a holder for OR-connected sub-lessons or a holder for AND-connected sub-lessons. The holder contains the actual sub-lessons in a specified order (as previously mentioned).

A lesson attribute contains, besides the sub-lesson holders, one or more pointers to domain concept attributes. This is the link with the concept domain. The idea is that the lesson puts pieces of information that are stored in the concept attributes together in a suitable way for presentation to a student. A sub-lesson which has no sub-lessons (e.g. is a leaf in the sub-lesson hierarchy) corresponds to a (one) concept attribute.

Figure 15 shows and example RDF instance of MOT, using the RDF Schema in Figure 14.

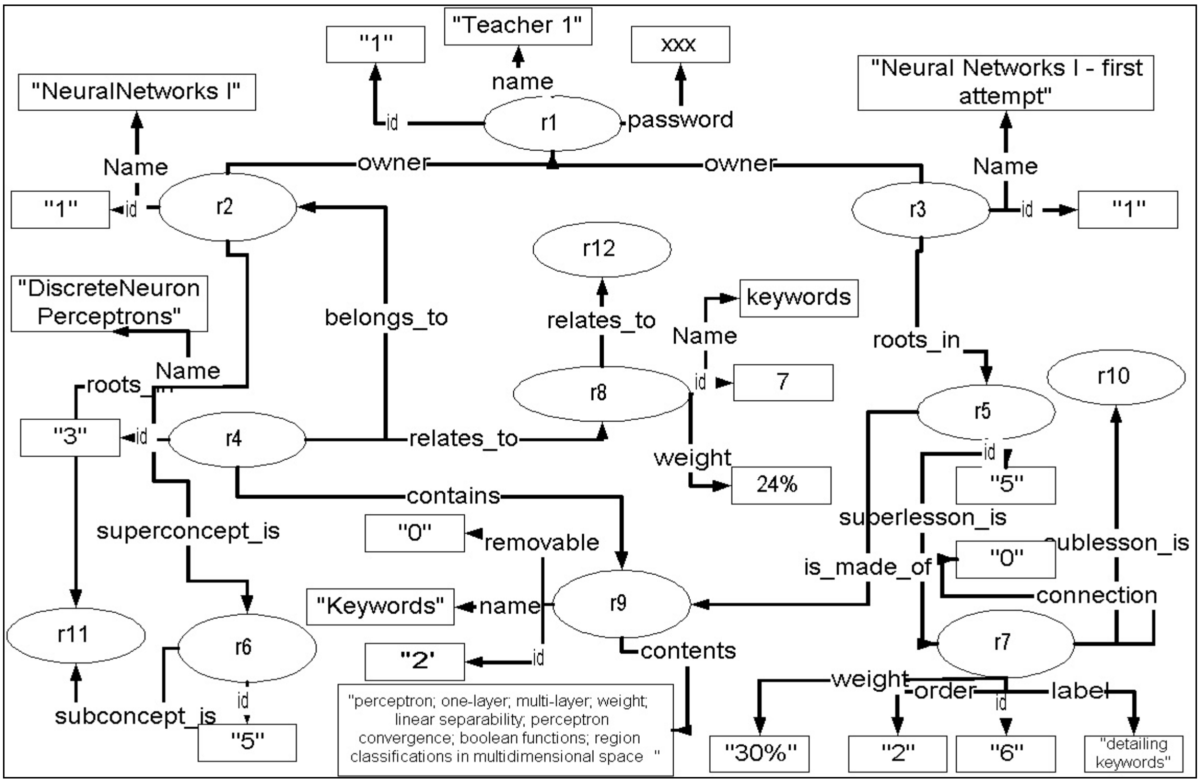

Figure 15. RDF Instance of two MOT layers (Cristea & De Mooij, 2003a).

For the domain map side (left hand side of Figure 15), we can see in the figure how concept *r11* is the root of the concept map *r2* owned by the designer *r1*. The concept *r4,* belonging to the same concept map is called "Discrete Neuron Perceptrons" and is a direct child of *r11*. Attribute *r9* called "Keywords" is contained in concept *r4* and contains the keyword list "perceptron; one-layer; multi-layer; weight; linear separability; perceptron convergence; boolean functions; region classifications in multidimensional space". Moreover, concept *r4* is related to concept *r12* via the attribute "Keywords" in a proportion of 24%.

For the goal and constraints map side (right hand side of Figure 15), the figure shows the previously mentioned attribute *r9* expressing the "Keywords" of concept *r4* as being assembled in sub-lesson *r5*, which is also the root of the lesson model. Lesson *r5* also contains sub-lesson *r10* in an OR connector (connection="0") with the weight 30%, the priority order "2" and the label "detailing keywords".

Conclusion

We have shown in this paper what the benefits can be for e-learning for joining the Semantic Web, as well as expanded on the possible synergistic effects of merging Adaptive (Educational) Hypermedia with the Semantic Web. We have shown that ideologically, these two fields share many commonalities, however, in practice only part of the Web Technologies are (successfully) being adopted.

Moreover, we have shown an exercise in integration by using Semantic Web languages to express LAOS, an Adaptive Hypermedia (authoring) framework and MOT, an authoring system for Adaptive Educational Hypermedia implemented based on the LAOS credo.

Semantic Web enthusiasts often encourage everybody to implement the new Web technologies, in order to bring the great promise of a 'web-of-meaning', step-by-step, iteration-by-iteration, closer to fruition. However, critics complain about the unripe technologies, about the lack of support, and about the problems with keeping the systems up-to-date with the ever newer versions of the standards. Moreover, critics mainly complain that there is too much extra work in addition to creation of resources (such as, the extra annotations of the created resources; the building of ontologies to match the resources; and finally, the merging of ontologies – a NP complete problem) and the return on this investment still lingers somewhere in the future.

However, given the amount of interest, effort and money put into the Semantic Web development, there seems to be less and less doubt that, eventually, it will deliver. Therefore, the question appears to be whether to adopt the standards early, fighting with all the associated problems but also having an influence on the solutions, or to join in when the technology and standards are ripe.

Standardization is something to be sought for, if interoperability is an issue. For e-learning there are other useful standards for specifications on the learning resources, such as the "Learning Objects Metadata Standard" (LOM) (http://ltsc.ieee.org/wg12/) by the Learning Technology Standards Committee (LTSC) of the IEEE, established as an extension of Dublin Core. A related standard is the SCORM, the Sharable Content Object Reference Model (http://www.adlnet.org/). Both attempt to foster the creation of reusable learning objects, in a similar manner to that of the Semantic Web. Another attempt is the effort towards standardization of the user (learner) information to be maintained by a (learning) system. Two standards of importance have emerged out of this effort, PAPI for Learner (Public and Private Information for Learner) (http://ltsc.ieee.org/wg2/ and http://edutool.com/papi/) and IMS LIP (Learning Information Package) (http://www.imsglobal.org/profiles/index.cfm). These standards define several categories for information about a user (learner).

For education and e-learning this means they must ask themselves the question if the extra-effort towards Semantic Web standards is *affordable* and *feasible*. The latter question we have explored with the example of an Adaptive Educational Hypermedia framework conversion into Semantic Web language. This exercise shows that, if the principles are aligned, the actual conversion is feasible, even if not always easy. The affordability is something to be decided on a case-by-case basis.

In this way, we have explored in this paper not only what the Semantic Web can do for Adaptive Educational Hypermedia, as declared in the title, but also how this conversion from Adaptive Hypermedia to the Semantic Web might be achieved.

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The New Challenges for E-learning: The Educational Semantic Web

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Abstract

The big question for many researchers in the area of educational systems now is what is the next step in the evolution of e-learning? Are we finally moving from a scattered intelligence to a coherent space of collaborative intelligence? How close we are to the vision of the Educational Semantic Web and what do we need to do in order to realize it? Two main challenges can be seen in this direction: on the one hand, to achieve interoperability among various educational systems and on the other hand, to have automated, structured and unified authoring support for their creation. In the spirit of the Semantic Web a key to enabling the interoperability is to capitalize on the (1) semantic conceptualization and ontologies, (2) common standardized communication syntax, and (3) large-scale service-based integration of educational content and functionality provision and usage. A central role in achieving unified authoring support plays the process-awareness of authoring tools, which should reflect the semantic evolution of e-learning systems. The purpose of this paper is to outline the state-of-the-art research along those lines and to suggest a realistic way towards the Educational Semantic Web. With regard to the latter we first propose a modular semantic-driven and service-based interoperability framework, in order to open up, share and reuse educational systems' content and knowledge components. Then we focus on content creation by proposing ontology-driven authoring tools that reflect the modularization in the educational systems, maintain a consistent view on the entire authoring process, and provide wide (semi-) automation of the complex authoring tasks.

Keywords

E-learning, interoperability, concept-based WBES, educational Semantic Web

Introduction

The Semantic Web vision significantly evolves the Web technology and advertises the opportunity to achieve seamless semantic understanding across cultures, time, geo-graphical borders, and technological platforms. The question is will this also bring us to the next evolutional step for E-learning?

The Semantic Web offers new technologies to the developers of Web-based applications aiming at providing more intelligent access and management of the Web in-formation and semantically richer modeling of the applications and their users. An important target for the Web application developers nowadays is to provide means to unite, as much as possible, their efforts in creating information and knowledge components that are easily accessible and usable by third parties. Within the context of Semantic Web, there are several hot issues, which allow achieving this reusability, shareability and interoperability among Web applications. Conceptualizations (formal taxonomies), ontologies, and the available Web standards, such as XML, RDF, XTM (XTM: XML Topic Maps http://www.topicmaps.org/xtm/), OWL, OWL-S (OWL-S: OWL-based Web service ontology), and RuleML (RuleML: The Rule Markup Initiative http://www.ruleml.org/), allow specification of components in a standard way. The notion of Web services offers a way to make such components mobile and accessible within the wide sea of Web information and applications.

The research on e-learning and Web-based educational systems (WBES) tradition-ally combines research interests and efforts from various fields. Starting from the traditional Intelligent Tutoring Systems (ITS), moving towards Web-based and hypermedia systems, we witness a growing interest in applying adaptation and personalization of the information offered to the users (e.g. learners, instructors and educational content authors). A characteristic aspect of this move is the attention the application needs to pay to the specific individual user in order to tailor the growing amount of information, coming from various distributed and local sources, to the needs, goals, roles and tasks of the individual users. In an effort to serve better the needs of the education community WBES attempt to employ Semantic Web technologies in order to achieve improved adaptation and flexibility for single and group users (e.g. instructors, courseware authors and learners) and new methods and types of courseware compliant with the Semantic Web vision. This promising class of Adaptive Web-based Educational Systems (AWBES) forms the basis of the emerging Educational Semantic Web.

The goal of this paper is to present and analyze the main aspects and research trends concerned with the development of a homogeneous e-learning Web space, where various systems collaborate in their effort to satisfy the users' needs and in the same time use state-of-the-art Web technologies to bring the e-learning to the level of the modern society developments. Our aim is to provide a ground for the design of more process-, context- and user-aware systems that facilitate efficient learning delivery, authoring and consumption. We first present four main aspects for achieving interoperability among WBES, including: concepts and ontologies for adaptive WBES, modularized adaptive WBES architectures, educational standards for the Semantic Web, and Semantic Web educational services. Then we discuss the importance of efficient authoring support covering the three central lines in the authoring of adaptive concept-based WBES.

Interoperability of WBES

Considering the constant increasing of resources on the Web (both static documents and functional components and software) it becomes almost impossible for the learners, authors and instructors to get an overview of all the available information relevant to their current needs, tasks, roles and goals. And even if they find some materials, which seem suitable, they are not able to assess completely whether the found content is entirely appropriate for their goals (for instructors) or current knowledge and cognitive state (for learners). Within the class of Web-based educational systems, a major role in various instructional contexts play the Educational Information Systems that are aimed at providing intelligent, task-centered information support for solving problems and performing learning tasks. Consequently, considerable effort is currently focused on defining frameworks and architectures to tackle issues of information sup-port from multiple perspectives. On the one hand, we do have the example of monolith Learning Management Systems (LMS), such as Blackboard (http://www.blackboard.com/) and WebCT (http://www.webct.com/), which on more or less superficial level cover various teaching, learning, and administrative activities and as a result provide Web-enhanced courses. On the other hand, we see multiple examples of specialized and effective educational systems and content providers, which support only one task/function within the entire educational process. Representatives of such systems are adaptive textbooks constructed with AHA! (De Bra et al., 2003), InterBook (Brusilovsky et al., 1998) and Net-Coach (Weber et al., 2001), or adaptive courses within ELM-ART (Brusilovsky et al., 1996), PAT (Ritter, 1997) and AIMS (Aroyo & Dicheva, 2001). There are also more global but still highly specialized efforts, such as ARIADNE (http://www.ariadne-eu.org/) and EdNa (EdNa: Educational Network Australia http://www.edna.edu.au/edna/page1.html) courseware-reusability frameworks that provide repositories of re-usable educational objects.

In order to support a richer set of educational functions and increase their effectiveness, such systems need to interoperate, collaborate and exchange content or re-use functionality. A key to enabling the interoperability is to capitalize on the (1) semantic conceptualization and ontologies, (2) common standardized communication syntax, and (3) large-scale service-based integration of educational content and functionality provision and usage. This view is supported also by Anderson & Whitelock' fundamental affordances for the Semantic Web: "The vision of the educational semantic web is based on three fundamental affordances. The first is the capacity for effective information storage and retrieval. The second is the capacity for nonhuman autonomous agents to augment the learning and information retrieval and processing power of human beings. The third affordance is the capacity of the Internet to support, extend and expand communications capabilities of humans in multiple formats across the bounds of time and space" (Anderson. & Whitelock, 2004).

Another semantic interoperability vision is given by Stuff & Motta, who envision “a multiplicity of community-based Semantic Learning Webs each with its own, perpetually changing ontologies, knowledge bases, repositories and ways of making sense of the world.”, where ontologies provide means for semantic communication within and across those “Knowledge Neighborhoods” (Stutt & Motta, 2004). Stepping on the above three factors for interoperability, we propose a powerful service-oriented framework to support efficient communication between component-based WBES (Dicheva & Aroyo, 2004).

The following sub-sections summarize the main aspects of adaptive WBES in the context of achieving interoperability in the Semantic Web.

Concepts and Ontologies in Adaptive WBES

We see that currently a considerable amount of the research on knowledge-based and intelligent systems moves towards concepts and ontologies (Aroyo & Dicheva, 2002; Devedzic, 2001; Mizoguchi & Bourdeau, 2000; Vasilakos et al., in press) and focuses on knowledge sharing and reusability (Chen et al. 1998; Ikeda et al., 1997). In general, an ontology is used to de-fine the basic terms and relations in the domain. It also provides axioms as rules and constraints for manipulating and managing the terms and their relations within this common domain vocabulary. Ontologies allow the definition of an infrastructure for integrating intelligent systems at the knowledge level, independent of particular implementations, thus enabling knowledge sharing (Breuker & Bredeweg, 1999). Together with various reasoning modules and common knowledge representation techniques, ontologies can be used as the basis for development of libraries of shareable and reusable knowledge modules (which take the form of software components) (Aroyo & Dicheva, 2002; Dicheva et al., 2003). As a consequence the research that focused on ontologies offers tools and technologies for reusing and sharing of knowledge and hence helps intelligent educational systems to move towards semantics aware environments.

There are a number of concept-based AWBES already developed (Aroyo & Dicheva, 2001; Brusilovsky, 2004; Brusilovsky et al., 1998; Aroyo et al., 2003; Dicheva et al., 2004; Dolog et al., 2004; Weber et al., 2001), which typically include: concept-based (ontology-driven) subject domain, repository of learning resources, course (learning task) presentation, adaptation & personalization. The fundamental feature of these systems is the subject domain conceptualization. It supports not only efficient implementation of their required functionality but also standardization: the concept structure can be built to represent a domain ontology that provides a broadly agreed vocabulary for domain knowledge representation. Thus the ontology specifies the concepts to be included and how they are interrelated. The repository contains learning resources (objects) relevant to the defined subject domain concepts. We can think of the resources as being attached to the domain concepts they describe, clarify, or use. If the attached learning resources have also a standards-based representation as opposed to a system-specific internal representation, this will insure that the application’s content is reusable, interchange-able, and interoperable.

Course/learning tasks are typically described/annotated in terms of subject domain concepts and some instructional relationships (such as ‘prerequisite’, ‘uses’, etc) between the involved concepts. The domain concepts are also used as a basis for implementing systems’ adaptive behavior. The latter involves constructing learner models in terms of subject domain concepts, performed tasks, and user profile characteristics.

An AWBES user is typically involved in exploring the subject domain ontology and searching the repository for information related to a specific task. Good examples of such systems are AIMS (Aroyo & Dicheva, 2001) and TM4L (Topic Maps for Learning) (Dicheva et al., 2004). AIMS and TM4L both focus on providing contextual support that enables learners to identify information necessary for performing a specific task (e.g. course assignment). Since both focus on efficient information provision and support for task-oriented problem solving, these systems are quite similar but they can be also seen as complementary in the way they support learning tasks. While AIMS includes course representation and sequencing, TM4L is a kind of digital library, which does not include direct course representation.

Educational Standards for the Semantic Web

The learning technology community is quickly adopting many of the Web technologies (XML, RDF(S), streaming video, etc.) (Devedzic, 2001). Simultaneously, the educational technology standardization is moving forward at rapid pace, with the IMS and the ADL having become the specification consortia that are tracked by vendors, implementers and academia. Both bring important contributions with respect to the management of educational resources. There is a growing concern though towards the need of extending the existent educational standards, such as the IEEE/IMS LOM standard (http://ltsc.ieee.org/wg12/), in the context of the Semantic Web so as to allow improved semantic annotation of learning resources.

The emerging educational specification for learning content SCORM addresses semantic annotations, content aggregation and sequencing. However, SCORM (SCORM 1.3 specification http://www.adlnet.org/screens/shares/dsp_displayfile.cfm?fileid=836) has chosen its own XML formats and methodologies, thereby limiting the educational community to a restricted universe, and making it much more difficult to integrate E-learning with other business processes. It is thus recognized by some, including leaders of the SCORM development community, that there is a benefit in opening up to the larger (Semantic) Web community. By design, these technologies make it easier to integrate learning material with other material by avoiding cumbersome translations of existing vocabulary and semantic descriptions.

It is important to consider effective specification of sequencing and annotation of material on a semantic level. One step towards achieving this is proposed in (Aroyo et al., 2003) by mapping the sequencing in the current SCORM standards onto OWL and DAML-S (http://www.daml.org/services/owl-s/). Such a DAML-S translation can then be used to integrate SCORM based learning environments with other business processes or Web services that have a DAML-S description.

Semantic Web Educational Services

In the current efforts targeting integration of various educational systems and content providers, Devedzic (Devedzic, 2003) proposes educational servers, which are based on using standards, ontologies, and pedagogical agents to support interaction between clients (authors and students) and servers (hosting educational content and services). He suggests that the interaction in the future educational systems will be between learners and services through educational service directories. While agreed with this vision, we believe that WBES interactions in the near to medium future will be between educational systems and/or their components, i.e. before achieving the large scale service-based integration, possible effective communications between systems and their components must be explored and exploited.

Another service-oriented perspective on the integration is given by the Elena project (Simon et al., 2003), which defines a smart learning space of educational service providers based on the Edutella (Nejdl et al., 2002) peer-to-peer framework for interoperability and resource ex-change between heterogeneous educational applications and different types of learning resource repositories. In the same context, we also see specific efforts trying to fill the gap between adaptive educational systems and dynamic learning repository networks, by proposing service-based architectures for personalized e-Learning. An example is the Personal Learning Assistant (Dolog et al., 2004), which uses Semantic Web technologies for realizing personalized learning support in distributed learning environments.

Modularized Adaptive WBES Architectures

The analysis of many current adaptive concept-based WBES shows that they share common architecture features. This enables the specification of a common reference architecture for adaptive concept-based WBES, which will allow for a more structured and common approach in their comparison, evaluation and building.

If we consider the problem of efficient construction of adaptive concept-based WBES that complement (serve as advisors to) each other by sharing resources and components, the obvious answer is a modularized approach in building such systems. This implies a component-based architecture that allows sharing knowledge (e.g. domain ontologies, learning resources, course models, and user models) and components (e.g. user modeling, course sequencing, ontology visualization, keyword search).

We have proposed such a general reference architecture (Dicheva & Aroyo, 2004) addressing the following research questions:

1. Level of granularity of information exchange: what should be the information contained in one communication transaction? For example, in the second scenario, should the author be allowed to ask about importing the entire domain model of another system in one transaction?
2. Request semantics: What kinds of questions the requesting system should be able to ask?
3. Request syntax: In what a form the questions should be expressed?

4. Domain or user model awareness: Should the requesting system send any indication about what it "knows" or its user already "knows", so that the responding system doesn't send information already known? If so, what kind of information and in what a form?

With regard to the grain size of exchanged information, we consider two issues as important for the communication quality and efficiency between the systems, (1) conciseness of the request and the reply, and (2) completeness of the request and reply.

Concerning the "understanding" between each other, the systems must "know" the basic terms for structuring and using ontology-based learning resource repositories, such as 'concept', 'relation/association', 'role in a relation', 'resource', etc., which make the common ground for the semantic understanding. In other words, the different systems must know how to map their internal knowledge to the basic concepts of this common ground. This lightweight mapping process, as opposed to very expensive reasoning processes, is a key aspect of the proposed approach. In this context we also propose using XML-based protocols, so that any application can "understand" them. In relation to the domain and user awareness we propose that the systems share a common user model, possibly through using a user modeling service. In that case the responding system will not need to ask the requesting system what the user already knows. A common (shared) user model is only feasible if all WBES systems within the framework have concept-based representation of their subject domain.

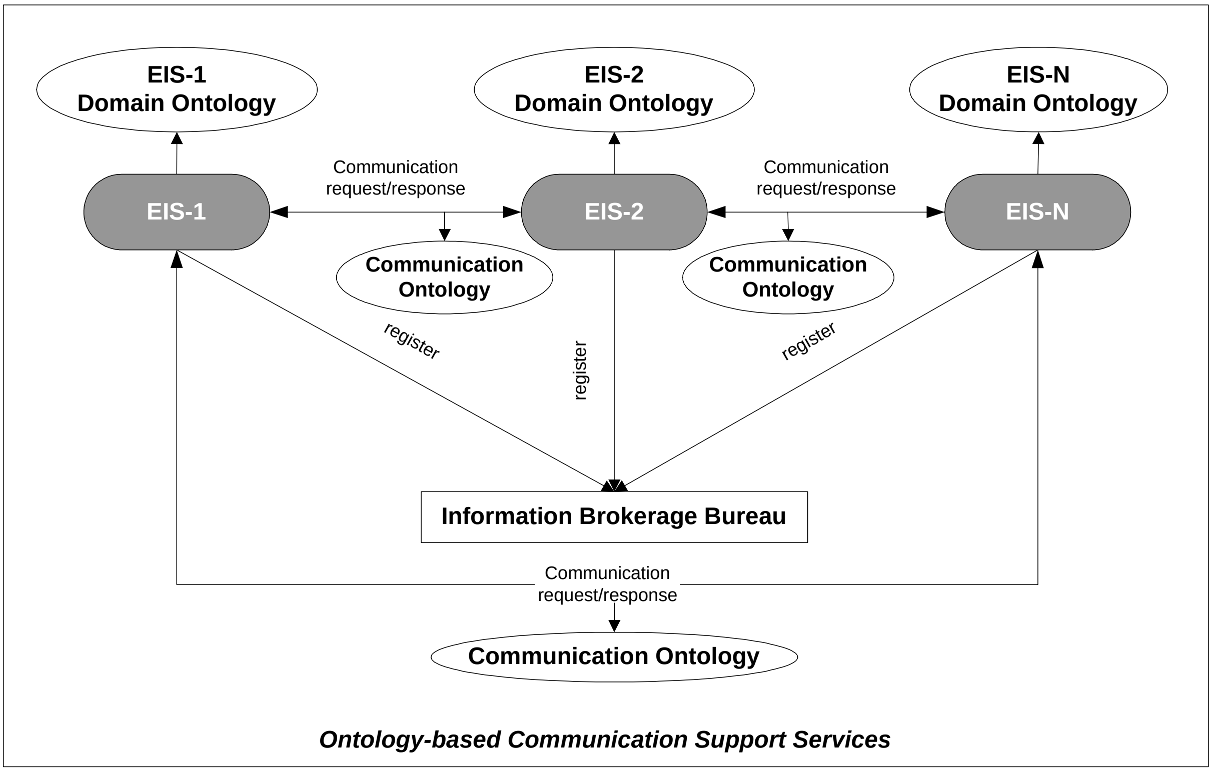

Figure 1. General architecture for component-based EIS interoperability

Thus, the proposed general architecture for supporting sharing and exchanging information between adaptive concept-based WBES include (Figure 1):

- Stand-alone, component-based independent WBES using their private subject domain ontologies.
- Information brokerage bureau where all applications are registered.
- Services to support systems communication, including ontology-related services, e.g. for ontology mapping.
- Communication bridges between the systems supporting standardized transport mechanisms and a common interaction protocol.

The communication between the systems requires not only standardized transport mechanisms and communication languages, but also common content languages and semantics. As to the communication semantics, in order for the applications to under-stand each other we propose using a communication ontology that defines the vocabulary of terms used in the messages at both message and content layers. To interpret the requests and answers standardized domain ontologies, UM ontologies, as well as up-per-level ontologies such as

WordNet (http://www.cogsci.princeton.edu/~wn/), SUMO (SUMO: Suggested Upper Merged Ontology http://ontology.teknowledge.com/), etc. can be used.

Authoring of Adaptive Concept-based WBES

Building adaptive concept-based WBES requires a lot of work and often is done from scratch. It becomes even more demanding with the constant increase of the information available on the Web and with the involvement of complex adaptation strategies for the instructional content presentation and navigation. A central problem in maintaining WBES popularity and benefiting from their wide use in practice is the fact that the current approaches for their building are rather inflexible and not efficient. The current way of designing such systems offers little space for reusing or sharing of content, knowledge and functional components. In addition, e-learning systems often lack a good authoring interface and require low-level programming skills from the content experts. The high and dynamic user demands in many aspects of software production are influencing research in the field of intelligent educational software as well (Major & Ainsworth, 1997). The ultimate problems are related to keeping up with the constant requirements for flexibility and adaptability of content and for reusability and sharing of learning objects and structures (Devedzic et al., 2000). Another problem in the current WBES research is that assessment of the existing systems is difficult as there is no common reference architecture, nor standardized approaches. Thus, there is an increasing need for efficient support environments for the designers and builders (authors) of adaptive WBES. We envisage that such support should include automatic or semi-automatic performance of some authoring activities, intelligent assistance to the authors in the form of hints, recommendations, templates based on recognizing different information patterns within subject domain content/ontologies or presentation (sequence) patterns, etc.

Considering the specification of modularized common reference architectures for WBES, the authoring of adaptive concept-based WBES should also be based on a strict separation and independency of the roles of the domain expert and the course author, which implies separate definitions of the domain knowledge (including also educational resources) and the instructional/course knowledge (including also the adaptation and personalization strategies) (Aroyo & Dicheva, 2004). We identify three groups of authoring activities: (1) authoring of the content, (2) authoring of the instruction process and (3) authoring of the adaptation and personalization. These authoring activities ensure structuring and editing of domain concepts and resources, modeling of the process of course task sequencing and choosing and applying an appropriate adaptation strategy.

A typical example of an authoring environment for an adaptive concept-based WBES is given by AIMS (Aroyo & Dicheva, 2002). Figure 2 shows the AIMS authoring environment, which supports the above groups of authoring activities via three tools that are typical for this class of systems: Domain Editing, Course Task Sequencing and Resource Management.

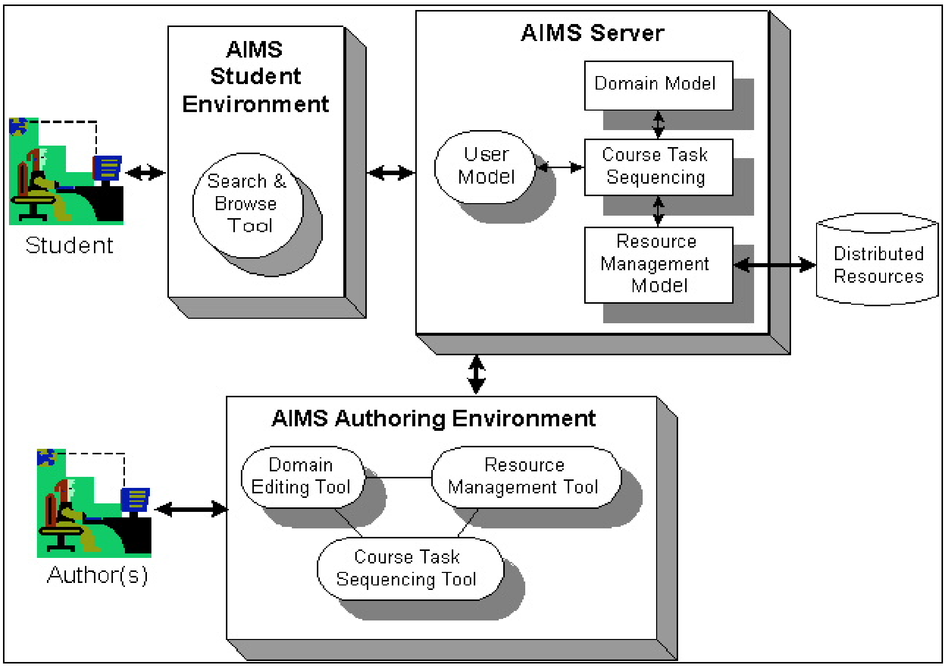

Figure 2. The global AIMS Architecture

The next three sub-sections illustrate the main aspects of authoring of educational content, instructional process and adaptation within the context of AIMS. Finally, in subsection "Process-aware Authoring Support for Adaptive WBES" we outline the main issues related to authoring tools employing the presented approach.

Authoring of Educational Content

Content authoring in adaptive concept-based WBES concerns creation of learning objects and their annotation (e.g. creation of metadata, marking-up), and involves creation of links (conceptual and functional) between those learning objects. At this level the authors perform domain-related and resource-related authoring activities.

Domain-related authoring activities: Constructing (editing and annotating) the do-main model in terms of concepts and links (from an externally or internally created subject domain ontology, a common vocabulary of terms describing the basic knowledge about the selected subject domain). A domain concept is defined as a pair consisting of the name of the concept and the corresponding set of attributes. A link de-fines an association between two concepts of a certain type with a given weight and in a specified link direction.

Resource-related authoring activities: Building a collection of educational re-sources in the resource library model (e.g. inserting new learning resources or editing existing resources in the resource repository). Each resource is enriched with the appropriate AIMS metadata to facilitate its further use within the course-sequencing module. (The metadata in AIMS is LOM-based (LOM IEEE P1484.12 Learning Object Metadata Working Group), which is an illustration of the use of standards-based data in these systems.). An interesting issue in the task-based WBES is the explicit attention to the resources. As opposed to conventional educational adaptive hypermedia systems, these systems usually maintain a clear separation between concepts and resources. First of all, this means that the handcrafting nature of adaptive hypermedia systems is out of the question, and that the application designer has to specify the design first at the level of abstract concepts, leaving their implementation by resources separate. At the same time, this allows later an extra dimension of adaptation, as the definition of the associations of resources and concepts can be programmed in such a way so as to realize personalization and adaptation.

Central to this separation of resources and concepts is the notion of conceptualization. The role of concept structures is to describe the content at the level of abstract concepts, but it is also a way to deal with the resource-concept separation. In educational applications it is common to reuse and exchange resources between applications, which means that learning objects are used in different course applications. To facilitate this, it pays off to base the conceptual structures on standardized metadata, so that the systems can easily offer different kinds of adaptation and personalization on a shared set of learning resources.

Authoring of Instructional Process

Authoring of the instructional process in concept-based WBES typically involves course construction activities, which include generating a course tasks model to represent a course structure and to serve as a basis for the further sequencing of course tasks. In order to produce an instructional task sequence the author usually (1) selects concepts from the domain model and assigns them to course topics; (2) selects specific sequences of course topics realizing the learning goals; and (3) assigns course tasks for each topic (each task will cover more than one learning activity).

Authoring of the Adaptation and Personalization

The authoring of adaptation considers user-related authoring activities that deal with the definition of user model attributes and their application in the adaptation and the course task sequencing (Dicheva et al., 2003). At this stage the authors typically define and apply various adaptation strategies in order to achieve the most efficient tailoring of the learning content to the individual learners.

In educational adaptive hypermedia systems, for instance, the adaptation primarily concentrates on the navigation structure and the construction of links and content in such a way that the presentation is adapted to the user. Even in the more general class of adaptive Web information systems the focus on navigation engineering is relatively high. In the adaptive task-based WBES the adaptation is styled quite differently, as the personalization is mainly constructed via the identification of tasks and the subsequent instructional sequencing.

Process-aware Authoring Support for Adaptive WBES

After discussing the different authoring activities we now turn to the authoring support tools. Many researchers in the field of educational systems have been focusing lately on authoring systems and their improvement (Kiyamaet al., 1997; Vassileva, 1995). Although the research field has already identified the main requirements for WBES authoring, still only very application dependant authoring systems exist and these do not focus neither on the reusability of the development efforts, nor on the applicability in different domains (Murray, 1999). As the application domains are multiple and serve various needs, the benefit of a common reference architecture would be significant.

The authoring approach that we present here in short, was introduced by (Aroyo & Dicheva, 2004) and further elaborated by (Aroyo et al., 2004). It focuses on the authoring at three levels of abstraction: (1) conceptual level, (2) application level, and (3) presentation level. It takes an onto-logical approach towards specifying the activities involved in application authoring. This means that a formal specification of the application authoring process is obtained, based on a definition of an authoring task ontology that captures in a task-oriented fashion the engineering activities involved in the application development, their requirements, constraints and results. An ontology-based representation of the application authoring process is a semantically enriched conceptual structure that can be used to support application authors. Figure 3 represents the architecture for the ontology-based authoring support realized by two modules, an operational module and an author-assisting module. The former is responsible for implementing the set of authoring tasks, while the latter is responsible for the immediate interaction with the author and for providing the actual support in the process of application authoring. In the case of educational applications, the operational module handles basic courseware authoring tasks related to information manipulation, consistency and possibly cooperation. It enables the process of domain creation, course structure building and educational resource management. The assisting module interprets the results of the op-erational module processing and gives hints to the author of how to edit the domain, how to create a course structure, how to link documents to the domain ontology or to course items, etc.

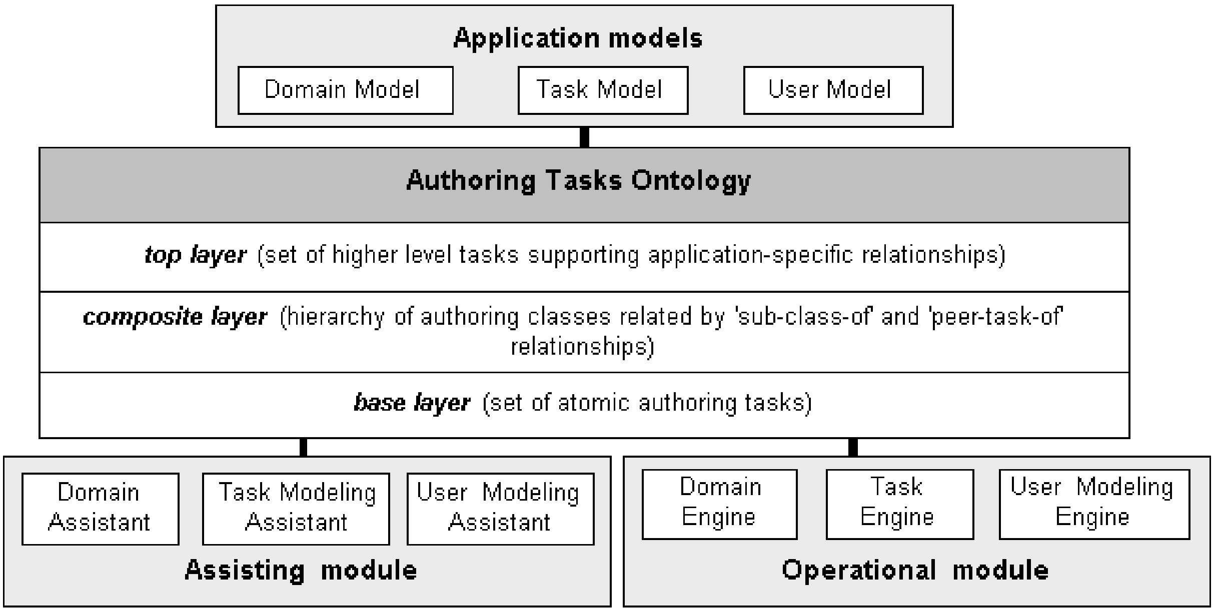

Figure 3. AWBES authoring support based on authoring tasks ontology

The design of the authoring task ontology involves three main layers (see Figure 3):

- A base layer with set of atomic authoring tasks (primitive functions).
- A composition layer including a hierarchy of authoring task classes that represent conceptual categories of relationships (interdependence) between primitive functions.
- A top layer including a set of higher level authoring tasks supporting application-specific relationships.

The atomic authoring tasks are primitive functional concepts, which are basic for the understanding and performing of the concept-based authoring process, and allow to build an ontology vocabulary. The primitive functions are defined on objects (e.g. concepts, links) within a specific concept-based structure (e.g. domain model). They express a simple functional formalism, where the object changes the structure, or the structure is manipulated. Examples of atomic authoring tasks include: Create (Structure), Create (Object), Add (Object, Structure), Delete (Object, Structure), Edit (Object, Structure), Link (Object1, Object2, Structure), etc. Note that such task definitions are independent of the information structure - the only prerequisite for the structure is to be concept-based.

In the composite layer there is a hierarchy of authoring classes related by 'sub-task-of' and 'peer-task-of' relationships: 'sub-task-of" represents (part-of) specialization between two tasks, while 'peer-task-of' relationships are viewed as a referral (is-a) mechanism to other authoring classes, which are considered as peers related to different contexts. These links can be weighted to represent the degree of relevancy as a peer. These relationships present certain aggregation criteria that are used for functional grouping primitive functional concepts (atomic authoring tasks) into higher-level authoring tasks (classes).

In the top layer, there is a set of application-related higher-level tasks to represent categories of application-specific relationships (including causal and other relations among authoring tasks). These relationships are not concerned with specific changes in the objects (concepts, links, resources), but represent specific functions in the concept based authoring process. The relationships may also represent the role (application dependent) of one authoring task for another authoring task. Examples are 'precedence' to represent a temporal relationship between two tasks, 'prerequisite' to represent a causal relationship between two tasks, or 'is-assigned-to', 'is-achieved-by', and 'is-delegated-to' to represent task-agent relationships.

To extract additional semantics for the authoring process from the authoring task ontology, there will be rules to query the ontology and find patterns and alternatives in the navigation within the network of authoring tasks. This can facilitate the work of authors aiming at a specific task. This would require a rule-based model over the schematic representation of the ontology to support the interpretation of its scheme and allow for extracting additional semantics that can be applied in the reasoning strategies of the authoring support tools. The rules will assign interpretations directly to the authoring task ontology graph (based on the RDF syntax), while the vocabulary of the graph is determined by the set of primitive functional concepts within the base layer.

Conclusions

To conclude, in the field of (A)WBES, it is clearly a transition stage, where the information is reaching critical amounts, the user demands for more personalized and adaptive system interaction are constantly rising, and the Web technologies are racing the clock to conquer new horizons. In this context, semantics plays a central role. It has become more explicit and this steadily changes the way in which we deal with information. Dealing with ontologies and concepts increases our conceptual awareness and influences the style of information perception, which reflects in the demands for using and authoring (A)WBES. The strive towards machine-readable semantics, on the one hand allows systems to more easily reach a conceptual agreement and exchange information and functional components. On the other hand, it provokes a 'greediness' to have more and more intelligence in the user-system interaction. With the new frame-works and architectures that are evolving in order to meet the semantic challenge the goal has become to provide the users (both students and authors) with a seamless personalized interaction with the WBES. It is unfeasible to predict, in the longer term, where e-Learning is going to go and what will be the new challenges then, but for now it is unambiguous that the current vision of the Educational Semantic Web propagates interoperability, reusability and shareability, all grounded over an extensive expression of semantics with a standardized communication among modular and service-oriented systems. An essential element for success is the availability of support for user-friendly, structured and automated authoring of educational systems, where it is important to find the balance between, on the one hand, exploiting explicit semantic information for agreement and exchange of educational information, and on the other hand, collecting and maintaining that information semantics.

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Ontology Enabled Annotation and Knowledge Management for Collaborative Learning in Virtual Learning Community

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Abstract

The nature of collaborative learning involves intensive interactions among collaborators, such as articulating knowledge into written, verbal or symbolic forms, authoring articles or posting messages to this community's discussion forum, responding or adding comments to messages or articles posted by others, etc. Knowledge collaborators' capabilities to provide knowledge and the motivation to collaborate in the learning process influence the quantity and quality of the knowledge to flow into the virtual learning community. In this paper, we have developed an ontology enabled annotation and knowledge management to provide semantic web services from three perspectives, personalized annotation, real-time discussion, and semantic content retrieval. Personalized annotation is used to equip the collaborators with Web based authoring tools for commenting, knowledge articulation and exertion by extracting metadata from both the annotated content and the annotation itself, and establishing ontological relation between them. The real-time discussion is used as a bridge to link collaborators and knowledge and motivate collaborators for knowledge sharing by building profiles for collaborators and knowledge (in the forms of content and annotation) during every discussion session, and establishing ontological relation between the collaborators and knowledge for the use of semantic content retrieval. The semantic content retrieval then utilizes the ontological relations constructed from the personalized annotation and real-time discussion for finding more relevant collaborators and knowledge.

Keywords

Ontology, semantic web services, metadata, annotation, collaborative learning

Introduction

Virtual learning communities (VLCs) are information technology based cyberspaces in which individual and groups of geographically dispersed learners and providers of knowledge to accomplish their goals of learning implement collaborative learning. They are designed information spaces which enable multi-authoring, using information in educational interactions, indicating information source, maintaining information, structuring information and adding meta-information, and sharing information among participants. VLCs have become growing initiatives during the past years for business organizations, educational institutions, and governments to pursue and mobilize knowledge via the Internet. The explosion in Web based technology leads to increasing volume and complexity of knowledge, which stimulates the proliferation of VLCs.

The literature of VLC demonstrates no agreement on what constitutes a virtual learning community. However, it has gained widespread acceptance that VLCs are knowledge based social entities where knowledge is the key to their success. An important activity in a VLC is the collaborative learning. Many VLCs 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 VLCs. 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 VLCs. As Leonard (1995) indicates, valuable knowledge collects in individuals' head and is embodied in machines, software, and routine processes. The participants need to understand precisely what knowledge will fulfill their needs, and to keep this knowledge on the cutting edge, deploy it, leverage it in performing their tasks, and spread it across the community. 'People' is thus herein considered as the second key element in VLCs.

The nature of the collaborative learning involves intensive interactions and exertion of knowledge effect. It cannot be achieved without the capabilities of the participants to manage their knowledge. These capabilities include articulating knowledge into written, verbal or symbolic forms, authoring articles or posting messages to this community's discussion forum, responding or adding comments to messages or articles posted by others, etc. Knowledge collaborators' capabilities to provide knowledge and the motivation to collaborate in the learning process influence the quantity and quality of the knowledge to flow into the knowledge reservoirs, while knowledge learners' capabilities to locate the knowledge collaborators and requested knowledge impact the learning outcome. Lacking the capabilities will impede the interaction among the participants and may finally fails the collaborative learning. The process of learning in VLCs mostly requires collaboration. However, if some piece of knowledge is ignored by most learners, there is no way that this knowledge can be acquired by simply collaboration. The facility to link the two key elements –knowledge, people- together is critical to the success of collaborative learning. Web based technology tools in this sense become the third key element of VLCs by linking the related knowledge and the individuals who possess valuable knowledge together.

In this paper, we have developed an ontology enabled annotation and knowledge management to provide semantic web services from three perspectives, personalized annotation, real-time discussion, and semantic content retrieval. Personalized annotation is used to equip the collaborators with Web based authoring tools for commenting, knowledge articulation and exertion. Our system has enhanced conventional annotation system by extracting metadata from both the annotated content and the annotation itself, and establishing ontological relation between them; in addition, we utilize such ontological relation to find more related content from either the annotation or the annotated content. The real-time discussion is used as a bridge to link collaborators and knowledge and motivate collaborators for knowledge sharing. Our system has enhanced conventional discussion board by building profiles for collaborators and knowledge (in the forms of content and annotation) during every discussion session, and establishing ontological relation between the collaborators and knowledge for the use of semantic content retrieval. The semantic content retrieval then can utilize the ontological relations constructed from the personalized annotation and real-time discussion for finding more relevant collaborators and knowledge.

Knowledge Management in Collaborative Learning

Despite the respective importance of knowledge, people, and technology in facilitating collaborative learning in VLCs, none of them determines its success alone. Collaborative learning involves a series of knowledge based activities, and thereby requires effective management of knowledge of the shared reservoir. Arthur Andersen and APQC's (1996) report states that knowledge can be accumulated by using technology to integrate people and information, and sharing the information among individuals to spread it across the organization. Davenport and Prusak (1998) indicate: "technology alone won't make a person with expertise share it with others." McDermott's study (1999) concludes that information technology could inspire but could not deliver knowledge management. Coleman (1988) also points out "if you are looking at collaboration and knowledge sharing, try to deal with the people/culture issues, the hard stuff, first."

The information processing view of knowledge management has been prevalent in information systems (IS) practice and research over the last few decades (Malhotra, 2000). However, a VLC is not merely an information processing machine, but an entity that creates and defines problems, and then further develop new knowledge through action and interaction. Researchers and academics have taken different perspectives on knowledge management, ranging from technological solutions to the communities of practices, and the use of the best practices (Bhatt, 2001). Knowledge management shapes the interaction pattern between people and technology. It helps to organize and implement a VLC's learning process. While the dynamics of a VLC are numerous and complex, understanding the concept of knowledge management will be conducive to the construction of the collaborative learning environment.

There have been several efforts at developing frameworks of knowledge management (Holsapple and Joshi, 1999). Some celebrated models include Wigg's (1993) framework of knowledge management pillars, Choo's (1996) framework of the knowing organization, and van der Spek and Spijkervet's (1997) framework of knowledge management stages, Leonard's (1995) framework of core capabilities and knowledge building, and Arthur Andersen and APQC'smodel of organizational knowledge management. Each of them addresses certain KM elements; however, none of them appears to subsume all of the others (Holsapple and Joshi, 1999). Given that a VLC is a learning environment supported by information technology, and the effective knowledge management cannot be achieved without a supporting learning platform and learners' capabilities to execute the course of actions (e.g., share, create, apply) required to manage knowledge, this study integrates the frameworks proposed by Leonard and Arthur Andersen and APQC, which both accentuate the roles of people, knowledge, and technology in manipulating the KM process.

Leonard introduces a KM framework comprising four core capabilities and four knowledge-building activities. The four core capabilities identified in this framework are physical systems, employee skills and knowledge, managerial system, and values and norms. She classifies the skills and knowledge by how much they are codified and their transferability. Also, she contends that technological competence accumulates not only in the heads of people but also accumulates in the physical systems. Physical systems are the software, hardware, equipment, and accepted procedures that reservoir the structured and codified knowledge. Such systems may enhance individuals' temporary or long-lived advantage, depending on learners' adapting and absorbing capabilities. The four knowledge-building activities that surround the core capabilities are shared and creative problem solving, implementing and integrating new methodologies and tools, experimenting and prototyping, and importing and absorbing knowledge. Capabilities grow through the activities undertaken by individuals. As Leonard stresses: "a core technological capability is a system partly comprising technical competencies in the form of: people's skills and the knowledge embedded in physical system".

Arthur Andersen and APQC propose a model of knowledge management which comprises two parts: KM processes and the enablers that facilitate the workings of the KM processes: The seven KM processes includes create, identify, collect, adapt, organize, apply, and share, while the four interrelated enablers are technology, measure, leadership, and culture. Technology and performance measure propel the operation of the seven processes to accelerate the knowledge collection, properly adapt and apply the knowledge, and allow people to retrieve the knowledge in a cost-effective way. Leadership and culture, however, deal with people issues. These two enablers facilitate not only the understanding of the task/job definition, the required knowledge in each stage of the work routines, and the methodology to apply the right knowledge in the right stage, but also the motivation for contributing, learning and continuous change for improvement. Each of the seven KM processes relates to each other and is influenced by the four enablers. The synergy of the four enablers and the seven processes will be the effective knowledge management, which in turn lead to value creation of the whole team.

Annotation in Knowledge Management

W3C defined annotation as comments, notes, explanations, or other types of external remarks, which attached to a Web document or a selected part of the document in Amaya project (2003). According to Euzenat (2002) mentioned, an annotation is the content represented in a formal language and attached to the document. Campbell (2002) addressed that annotation provides commentary on information objects at other times and usually by others people. It facilitates the access and use of information on World Wide Web. Aiken, Thomas and Schennum (1976) pointed out material that was in a learner's notes were twice as likely to be recalled as material that was not in the learner's notes. Shimmerlick and Nolan (1976) mentioned the group who took reorganized notes recalled more of the passage on an immediate test than the sequential notes group as well as on a delayed test given one week later. In addition, the result shows that the effects of reorganizing note taking were particularly strong for students who were not above average in verbal ability. Based on mentioned studied, annotation is an important learning reference, which supplement and enhance the acknowledgment of course content. IIes, Glaser, Kam, and Canny (2003) proposed a shared whiteboard system running on wireless handheld device. Anselm (2002) proposed a visual interface to index and allows people using their handwriting note or text notes to retrieve and share specific media component. Annotation can benefit learning in the following categories:

1. Attention: help students to focus on annotated concept or specified sentence.
2. Discussion: help students to discuss assignment based on each one's aspect in an efficient manner.

3. Organization: help student construct his own knowledge based on annotations, remind him the important concepts.
4. Indexing: using bookmark to indicate the annotated objects, using anchor to bind the annotation to annotated object, facilitating the personalized knowledge discovery in view of information retrieval.

For a specific content, people may have a variety of comment. Experienced people, likes experts, senior engineers, or managers, write down their opinions, which are valuable to improve overall performance. It is very important to respect, preserve and share other people's viewpoints. In this paper, we called these viewpoints as "personalized annotation". How to efficiently and effectively manage personalized annotation is a challenging and must need problems.

Euzenat (2002) pointed out annotation need to be close relation with it use. In his study, ontology, background knowledge and annotation enable the reconstruction of content. It provides a methodology of annotating with formal content. The behaviors of sharing annotation are discussed in Sannomiya's (2001) study, such as writing annotation, browsing annotation and feedback. In past decade, several metadata schemas have been proposed to describe learning content, such as Dublin Core (DCMI, 2004), Learning Object Metadata (LOM, 2004), and Shareable Content Object Reference Model (SCORM, 2004). These metadata schemas are designed to provide semantic information adhered to E-document. User can use this information to retrieve related learning resource. In 2001, W3C has proposed web-based shared annotation system based on a general-purpose open RDF infrastructure, called Annotea (Kahan, 2001). User can use Amaya to browse content and make annotation through Annotea. This annotation can be stored either in annotation severs or in local end. To associate annotation with content, Annotea use XPointer technology to insert annotation position within XML document. It implies initial state of content modified, after adding annotation. Due to the maintenance of linking relations, XPointer is suitable for static documents, but not for frequently changed document. A "pencil-icon" appeared to indicate an annotation existed. To sharing others annotation, Annotea provides discussing-board like mechanism to let people review others opinion. A specific querying request service is not supported. Microsoft has published OneNote (2001), which is a personalized annotation system. User can choose pen, keyboard or voice to input his annotation. The note or annotation is shared only by e-mail. This limits the usage of annotation.

One purpose of the semantic Web services is to improve content retrieval by automating computers to read and understand digital content resources such as MS word, PowerPoint, Adobe PDF, HTML, XHTML, SMIL, which are all referred to e-document in this paper. To facilitate the use of computing process, personal annotation should be established in a machine readable format and closely related to the annotated object (could be sentence, paragraph or picture). There are three major issues on annotation management; the first issue is the annotation anchoring which address how to increase the precision of annotation's spatial position with respect to the annotated objects. The second issue is the personalized annotation which addresses how to distinguish annotation's belonging and retrieval the right annotation when multiple collaborators are making annotations in a same e-document. The third issue is the semantic annotation retrieval which addresses how to find more related annotated objects, annotations, and collaborators. Take an annotation "OWL-S" for example, we can find more annotations and their annotated objects related to this "OWL-S" and the collaborators who made the annotations, as well as the e-document and the authors encompass the annotated objects.

Personalized Annotation Management

We have developed a personalized annotation management (PAM), which consists of four functional modules, and three repositories as shown in Figure 1. The functional modules include Annotation Creation, Anchoring, Annotation Review, and Real-time Discussion Board. The e-documents, annotations, and semantic metadata are stored in e-document, annotation, and knowledge repositories, respectively. Users can retrieve e-document from e-document repository and write his annotation into Annotation Repository. Before e-document and Annotation stored into repositories, all the information will be parsed and classified into clusters based on extracted semantic in Knowledge Repository. When users request for an annotation through the "Annotation Review" module, system will computes the similarity of the requested annotation based on the semantic metadata stored in the knowledge repository and reply matched or partial matched results to users. Anchor mechanism provides the binding service to associate annotation with corresponding annotated objects. Through the Real-time Discussion Board, users can interchange their opinions by making and reviewing annotations online. The related discussion log is saved for further Web mining and user behavior analysis.

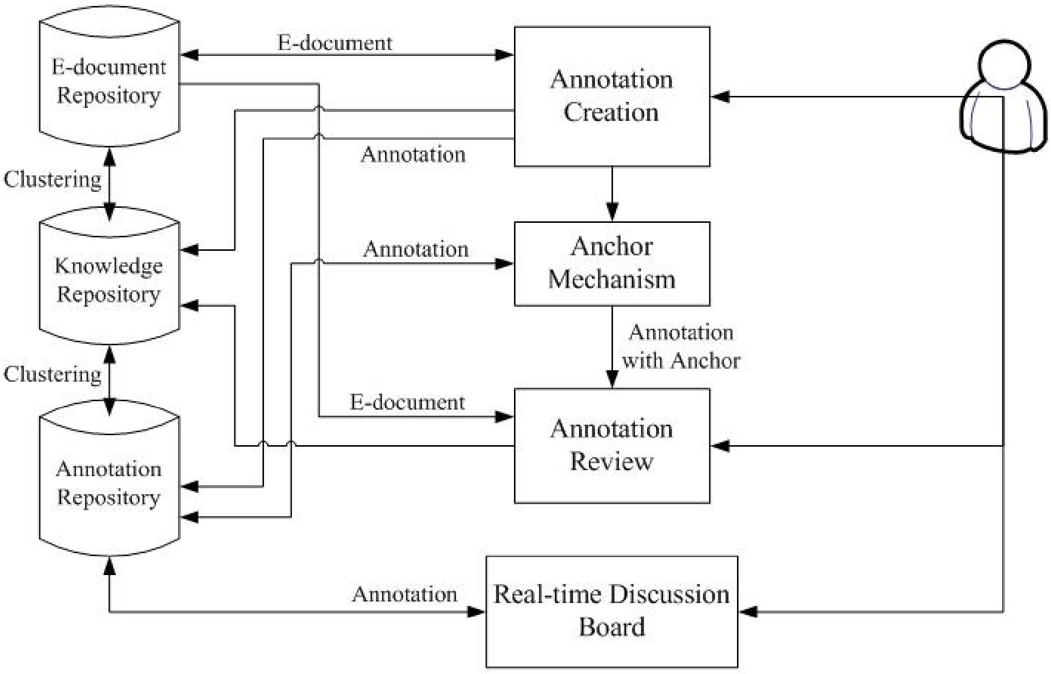

*Figure 1***.** Architecture of Personalized Annotation Management

We have developed two models to describe the two core objects in PAM, the content model for the annotated objects, and annotation model for the annotation.

Content Model

A content model is defined by a content profile and a content process model. A content profile consists of three metadata to describe e-documents in html format. The three metadata are core metadata, structural metadata, and behavioral metadata. The relationship of the three metadata is depicted in Figure 2.

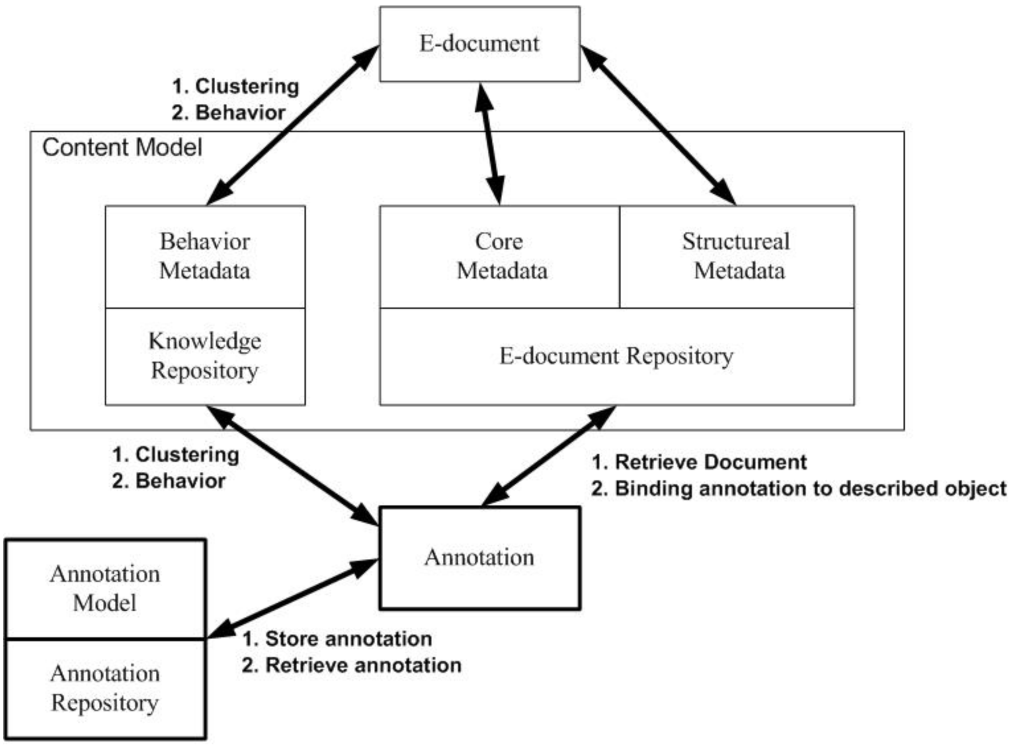

Figure 2. Using content model to describe resources of e-document

Core metadata contains 13 attributes to describe primitive attributes of an e-document. The 13 attributes are described as follows:

Attributes	Description
Document_Title	e-document's title
Document_Description	topic of the e-document
Document_Creator	entity for making the content of the resource
Document_Identifier	account of the content of the resource
Document_Publisher	entity responsible for making the resource available
Document_Date	date of an event in the lifecycle of the resource
Document_Content_URI	reference to a resource from which the present resource derived
Document_Type	nature or genre of the content of the resource
Document_Structure	reference with decomposed objects of present resource
Document_Format	physical or digital manifestation of the resource
Document_Language	language of the intellectual content of the resource
Document_Relation	reference to a related resource
Document_Annotation_ID	reference with related annotation of present resource

Structural metadata contains five attributes to describe the structural properties of the objects encompassed in an e-document. The five attributes are described as follows:

Attributes	Description
Object_ID	identifier of each object
Object_Type	type of object, likes text, image, audio
PreObject	object in front of the annotated object
SucObject	object successive to the annotated object
Document_Identifier	identifier of corresponding e-document

Behavioral metadata contains three attributes to describe the behavioral relationship such as inter-document relationship, inter-annotations relationship, and inter-document-and-annotation relationship.

Attributes	Description
Inter_Document_relation	describe the similar semantic cluster derived from document in ontology-based aspect
Inter_Annotation_relation	describe the similar semantic cluster derived from annotated document in personal aspect
Inter_Document_annotation_relation	describe implied relations from annotation cluster to document cluster or vice versa

All kinds of e-documents, such as HTML, WORD, PowerPoint, etc, can be represented in markup languages by content model. In this paper, we emphasize personalized annotation management and exploit the relation with E-document.

Content process model defines processes for serving the Web content described by the content profile. In this model, service process can be classified as atomic process and composite process. An atomic process is the most primitive building block for providing content service. Composite process is a combination of several atomic processes.

Annotation Model

Annotation management must provide annotation retrieval besides annotation creation and browsing. Therefore, in addition to using content model to describe the annotated e-documents, we also need an annotation model to describe the annotation itself.

Annotation Model ($AM_{u,i}$, where *u* represents annotator and *i* indicates Annotation_ID) contains eight attributes to describe the primitive properties of the annotations encompassed in an e-document. The eight attributes are described as follows:

Attributes	Description
Annotation_ID	unique identifier of an annotation
Annotation_Name	name of the annotation
Annotation_Type	indicates types of annotations such as commentary, question, explanation, bookmark, sketch, drawing, and link
Annotation_Format	indicates formats of annotation such as text, graph, and voice
Annotation_INK	reference to annotator's handwriting
Annotation_Description	describes the context of the annotation
Annotator	indicates the author of the annotation
Anchor_Position	contains the anchoring position of the annotation in the e-document

Ontological Relation between Content and Annotation

There are two important ontological relations between annotation and the annotated e-document as shown in Figure 3, which we can derive from annotation creation and annotation anchoring. One is an association relation to associate an annotation to its annotated object. The other is a spatial relation to place an annotation to its annotated object's position in an e-document. Based on the association and spatial relations, we have developed an anchoring process as follows:

1. Retrieve structural metadata (SM_I) of the annotated e-document (Document_Content_URI in CM_I)
2. Specify the desired annotated object (Object_ID in SM_I)
3. Compute anchor position which consists of a start and a stop position of the anchor (Anchor_Position of $AM_{u,i}$) based on specified object (Object_ID).
4. Write down the note (Annotation_INK) via Annotation pad.
5. Recognize handwriting note (Annotation_INK) as digitalized text format (Annotation_Description)
6. Store handwriting and recognize text information with anchor position, i.e. established Annotation Model established ($AM_{u,i}$)

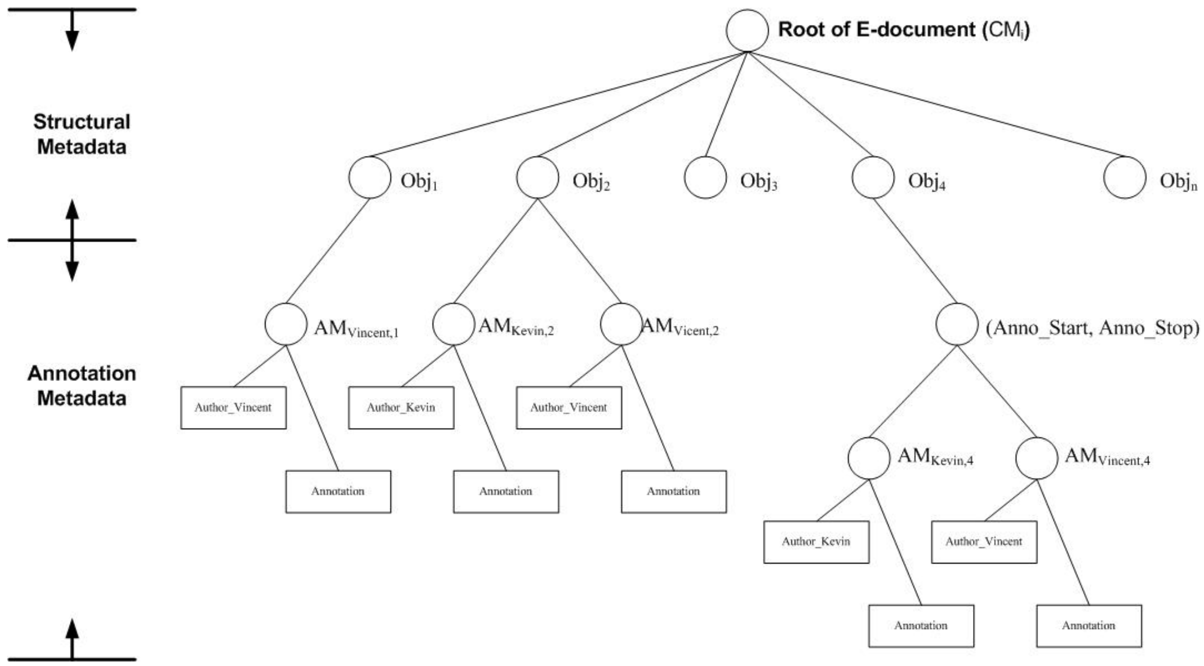

Figure 3. Ontological tree denoting relation between annotation and e-document

This anchor's position is added to XSL file, which support the styling function. With XSL technology, annotation can be invoked and incorporated into e-document during browsing without modified to the original copy. In this way, the separated annotation and e-document can be merged as user requests. In addition, we apply content adaptation techniques to this XSL-based anchoring mechanism and make anchors and the annotated annotation displayed adaptively depends in which types of devices are used for annotation browsing.

Annotation Creation and Storage

Annotation as shown in Figure 4 can be created by either a single user or multiple users to annotate specified objects in an e-document.

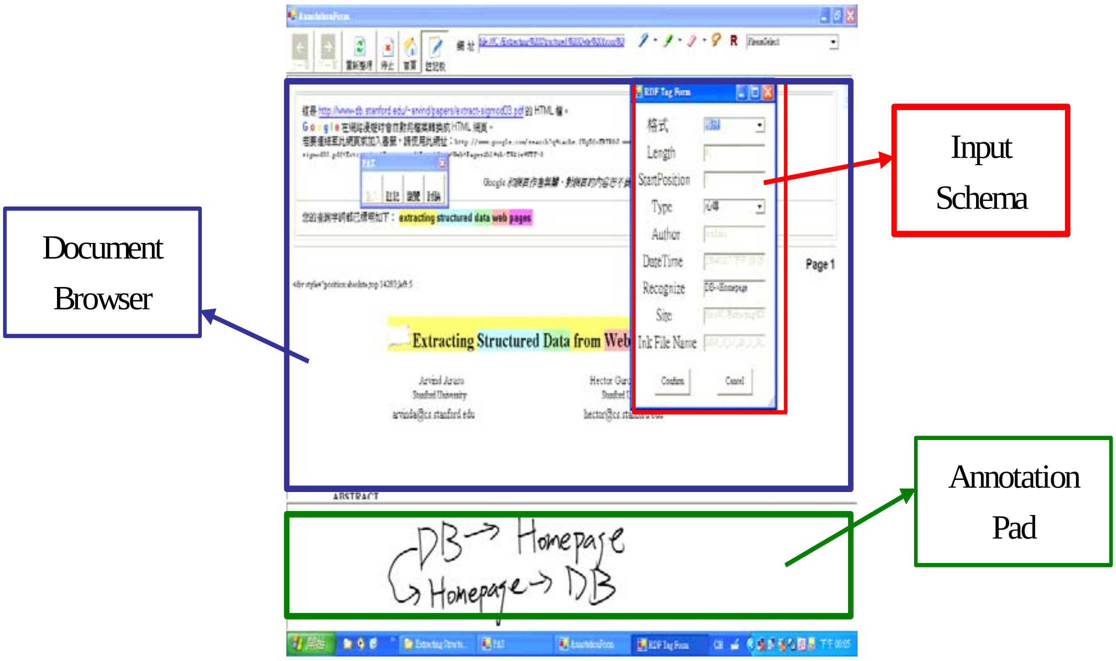

Figure 4. Annotation Editor

For the case of a single user annotates a specified object, likes subtitle, paragraph or image. Let an e-document has been interpreted by content model, denoted as CM_i. A user annotated a specified object in this e-document via annotation model $AM_{u,i}$. This annotation could be bound to a specified object in the e-document by means of object and e-document identifier. For example, in Figure 3, the ontological relation between $AM_{Vincent,1}$ with Obj_1 depicts this case. For the case of multiple users annotate on a same object. Let user A and B annotated on a same specified object in an e-document denoted as CM_i via two annotation model $AM_{a,i}$ and $AM_{b,i,}$ respectively. This annotation could be bound to the specified annotated object in this e-document by means of object, e-document identifier, and annotator. For example, in Figure 3, the ontological relations between $AM_{Kevin,2}$ and $AM_{Vincent,2}$ with Obj_2 depict this case. For the case of semantic clustering of annotations, we have developed a clustering mechanism and based on the attribute Annotation_Description of $AM_{u,I}$ to compute annotation's similarity in terms of semantic meaning and categorize them into related clusters. The result of annotation clustering is that we can establish inter-relation between annotations, which can be saved as behavior metadata in content model. Similarly, we can cluster e-document and establish the inter-relation among e-documents. These relations of inter-annotation and inter-E-document can be represented in a term-document matrix format as shown in Table 1. From Table 1, we found that annotation $AM_{x,070}$ is related to $AM_{y,090}$ through term "mobile learning". When users review the annotations associated to an e-document CM_{090}, they can further search for additional annotation related to "mobile device", and through this, they can find more related e-document about "mobile device".

Table 1. Term–Document Matrix

Cluster $_i$	$AM_{Bormida,070}$	$AM_{Sharples,070}$	$AM_{jones,070}$	$AM_{Bijorn,090}$	$AM_{Sutinen,090}$	…	$AM_{Smordal,100}$
personalized metadata	1	1	1				
adaptive mobile learning	1	1	1	1	1		
mobile learning	1	1	1	1	1		
multi-sensory learning				1	1		
pervasive learning				1	1		
mobile devices	1		1	1	1		
handhold devices				1	1		1
…							

Figure 5 shows the relations among annotations and e-documents. The annotations described by annotation model (*AM*) are stored in annotation repository, the e-documents described by content model (*CM*) are stored in e-document repository, and the relation among *AM* and *CM* are stored in knowledge repository. Although user can trace e-document by means of corresponding annotations and vice versa, there are some other useful information need to be exploited. In author's perspective, the relations among annotations and the corresponding annotated e-documents imply personalized knowledge which is associated with semantic knowledge. Therefore, during information retrieving process, the searching scope could be extended or restricted by reasoning the knowledge repository to improve the search performance.

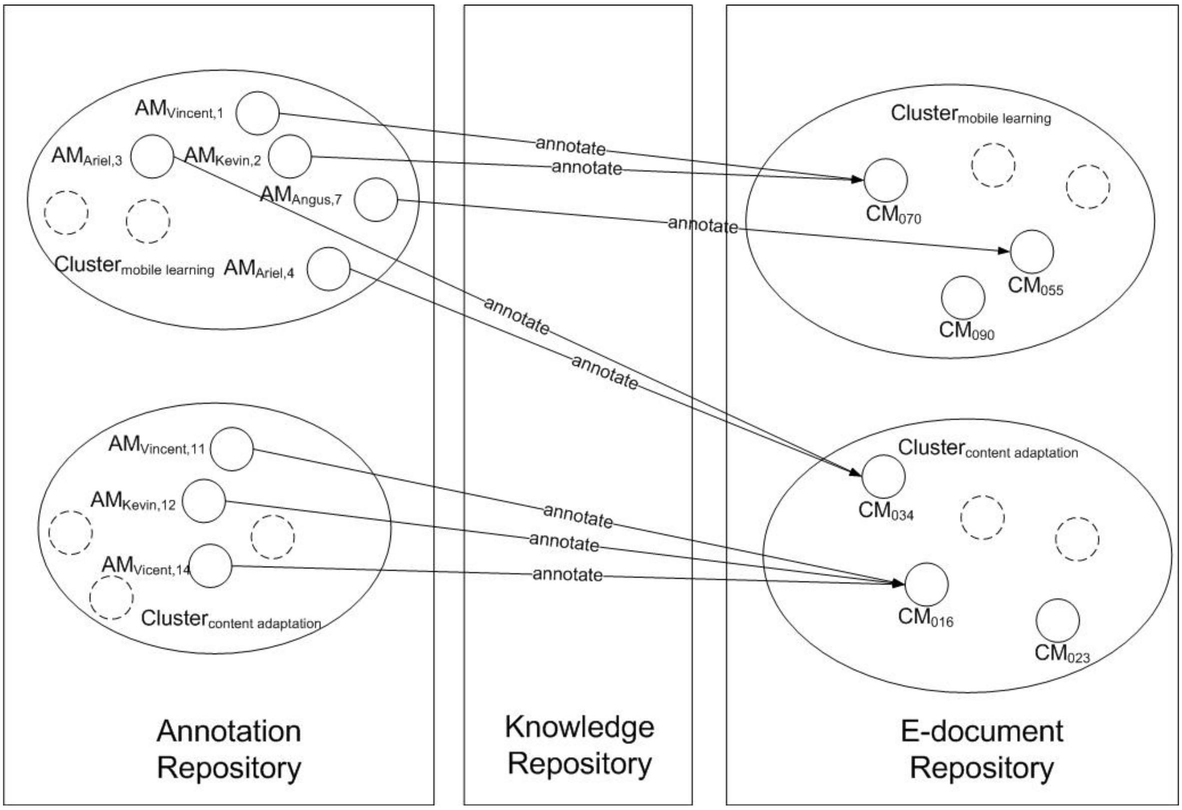

Figure 5. an example of relations among annotations ($AM_{i,j}$) and e-document (CM_k)

Real-Time Group Discussion

Let various collaborators are gathering and making their annotations regarding a specific subject via a real-time discussion board as shown in Figure 6, if we put all the annotations made by various collaborators in the same content model, the individual aspect of each collaborator might be ignored or simply lost. Besides, sharing individual's annotation to the public is a violation of privacy. Therefore, our approach is to gather all collaborators' annotations to establish a group annotation representing the group's aspect regarding the discussion subject.

For the case of group discussion, let members of a discussion group can review all the annotations made by the others denoted by $AM_{u,i}$, where $u = 1,..m$, and let the annotated e-document denoted as CM_i. Based on our anchoring mechanism, these annotations made by the same group can be aggregated, organized and displayed as a group annotation denoted by $AM_{m+1, i+1}$, and associated with the annotated e-document, CM_i.

Semantic Content Retrieval

We classify all annotation models and content models into clusters based on concepts which can be inference to be semantically similar. For example, OWL and OWL-S are classified in the same cluster with concept "semantic Web" since they are both ontology for describing semantic web services. Based on the clustering and ontological relation between annotation model and content model, we can extend a conventional search to a semantic search as follows:

1. User input query, system will identify the query (q_i)
2. Computing the similarity between query and concept of clusters, and determine possible cluster,
3. Confine search domain to possible clusters in annotation repository,
   (1) Compute the similarity between each query (q_i) with each annotation model ($AM_{u,j}$)
   (2) Assign a repository weight (w_{anno}, for example 0.6) to corresponding result ($AM_{u,j}$),
   (3) Rank all candidates based on weighted similarity ($w_{anno} \times AM_{u,j}$).
4. Confine search domain to possible clusters in e-document repository,
   (1) Compute the similarity between each query (q_i) with each e-document, content model (CM_j)
   (2) Assign a repository weight (w_{docu}, for example 0.4) to corresponding result (CM_j),
   (3) Rank all candidates based on weighted similarity ($w_{docu} \times CM_j$).
5. Rate the matched results from annotation and e-document repository. When weighted a similarity ($w_{anno} \times AM_{u,j}$ and $w_{docu} \times CM_j$) is great than a predefined threshold (TH_{basic}), then
   (1) Case 1: If the weighted similarity ($w_{anno} \times AM_{u,j}$ and $w_{docu} \times CM_j$) directs to same e-document, then assigned extra weight to this weighted similarity ($1.5 \times w_{anno} \times AM_{u,j}$ or $1.5 \times w_{docu} \times CM_j$).
   (2) Case 2: If the weighted similarity ($w_{anno} \times AM_{u,j}$ and $w_{docu} \times CM_j$) directs to different e-document, then no extra weight will be assigned.
   (3) re-arrange the sequence of e-document base on the result of weighted similarity, and then reply to user for selection
6. If there is no qualified candidates to reply to user, system will ask user refine input query.

For example, according to clustering theorem, all e-documents in same cluster are similar in semantic level. Same case applied to annotation. From Figure 5, tracing annotations in $Cluster_{mobile\_learning}$, it can be found that $Cluster_{mobile\_learning}$ and $Cluster_{content\_adaption}$ in e-document repository are related.

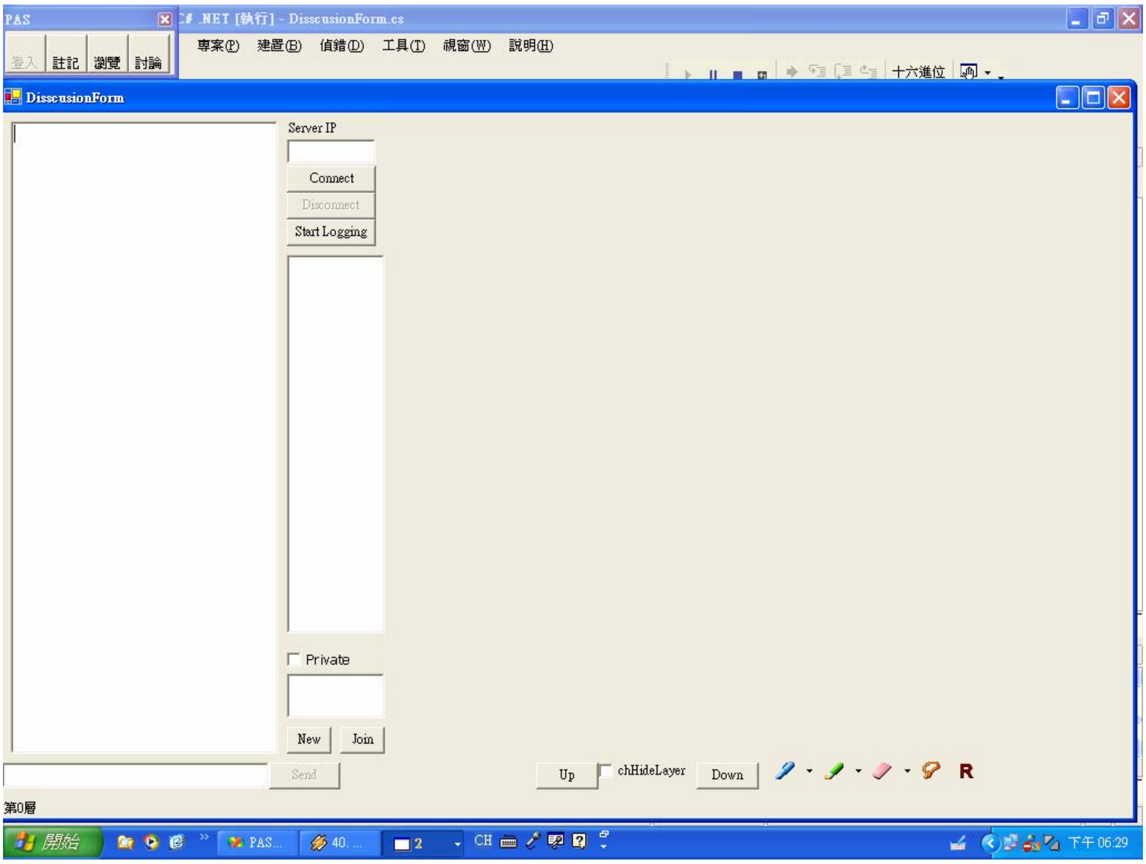

Figure 6. A Real-time group discussion board

Conclusion and future Research

In this paper, we have proposed two metadata models, content model and annotation model to formally describe content and annotation, respectively. In addition to utilizing the two models to formally describe content and annotation, we also derived ontological relation between the two models to lift the two models from syntax to semantic level. We have built an ontology enabled annotation and knowledge management system to demonstrate our ideas. The system not only provides annotation creation and clustering for annotation and knowledge management, but also provides real-time discussion for collaborative learning, and a query-by-annotation for semantic search. In our future research, we will enhance the current system to be universal access that is to make the annotation creation and browsing through various devices, to make the real-time discussion mobilized, and make the semantic search more context awareness to meet the collaborator's need by extending the knowledge repository with additional user profiles, device profile, and service profiles.

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Reasoning and Ontologies for Personalized E-Learning in the Semantic Web

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Abstract

The challenge of the semantic web is the provision of distributed information with well-defined meaning, understandable for different parties. Particularly, applications should be able to provide individually optimized access to information by taking the individual needs and requirements of the users into account. In this paper we propose a framework for personalized e-Learning in the semantic web and show how the semantic web resource description formats can be utilized for automatic generation of hypertext structures from distributed metadata. Ontologies and metadata for three types of resources (domain, user, and observation) are investigated. We investigate a logic-based approach to educational hypermedia using TRIPLE, a rule and query language for the semantic web.

Keywords

Educational hypermedia, Semantic web, Ontologies, Adaptive hypermedia, Reasoning on the semantic web.

Introduction

The vision of the semantic web is to enable machines to interpret and process information in the World Wide Web in order to better support humans in carrying out their various tasks with the web. Several technologies have been developed for shaping, constructing and developing the semantic web. Many of the so far developed semantic web technologies provide us with tools for describing and annotating resources on the web in standardized ways, e.g. with the Resource Description Framework (RDF) (RDF, 2002) and its binding to XML e**X**tensible **M**arkup **L**anguage (XML, 2003). In this paper we will show how semantic web technologies and in particular ontologies can be used for building adaptive educational hypermedia systems. Adaptive educational hypermedia systems are able to adapt various visible aspects of the hypermedia systems to the individual requirements of the learners and are very promising tools in the area of e-Learning: Especially in the area of e-Learning it is important to take the different needs of learners into account in order to propose learning goals, learning paths, help students in orienting in the e-Learning systems and support them during their learning progress.

We propose a framework for such adaptive or personalized educational hypermedia systems for the semantic web. The aim of this approach is to facilitate the development of an adaptive web as envisioned e.g. in (Brusilovsky and Maybury, 2002). In particular, we show how rules can be enabled to reason over distributed information resources in order to dynamically derive hypertext relations. On the web, information can be found in various resources (e.g. documents), in annotation of these resources (like RDF-annotations on the documents themselves), in metadata files (like RDF descriptions), or in ontologies. Based on these sources of information we can think of functionality allowing us to derive new relations between information.

Imagine the following situation: You are currently writing e-Learning materials for higher education. Especially in e-Learning, it is important to overcome the *one-size-fits-all* approach and provide learners with individual learning experiences. Learners have different requirements (like their individual learning style, their actual progress in the learning process, their individual background knowledge, but also more technical requirements like the device they are currently using for accessing the E-Learning materials, etc.). The e-Learning system you would like to use should provide such a personalized delivery of e-Learning materials. How can you describe instructional material in a way allowing for personalized e-Learning?

In our solution for personalized e-Learning systems we envision personal learning services capable of interpreting metadata-annotated learning resource, *understanding* their annotations with respect to standard ontologies for learning materials like e.g. LOM (LOM, 2002) or IMS (IMS, 2002), and also with respect to specific domain ontologies which describe the particular subject being taught. To enable personalized delivery of the learning resources, ontologies for describing the learner and observations about the learner's interactions with the e-Learning system are required to characterize and model a learner's current profile.

Each personal learning service possesses reasoning rules for some specific adaptation purposes. These rules query for resources and metadata, and reason over distributed data and metadata descriptions. A major step for reasoning after having queried user profile, domain ontology and learning objects is to construct a temporally valid task knowledge base as a base for applying the adaptation rules. The concluded results of these personal learning services are described using the presentation format of the open hypermedia standard.

The paper is structured as follows: In the following section, we will compare our approach with related work. Section 3 describes the representation of resources with semantic web technologies, and shows our use of a domain, user, and observation ontologies. Section 4 discusses our approach to generate hypertext structures / associations, and an example set of rules for dynamically generating personalized associations between information. A comparison of our approach to related work and a conclusion end the paper.

Related Work

To describe and implement personalized e-Learning in the semantic web, there are at least three related research areas which contribute: *open hypermedia*, *adaptive hypermedia,* and *reasoning for the semantic web*. Open hypermedia is an approach to relationship management and information organization for hypertext-like structure servers. Key features are the separation of relationships and content, the integration of third party applications, and advanced hypermedia data models allowing, e.g., the modelling of complex relationships. In open hypermedia, data models like FOHM (Fundamental Open Hypertext Model) (Millard et al., 2000) and models for describing link exchange formats like OHIF (Open Hypermedia Interchange format) (Gronbaek et al., 2000) have been developed. The use of ontologies for open hypermedia has e.g. been discussed in (Kampa et al., 2001). Here, ontology is employed that clarifies the relations of resources. On base of this ontology, inference rules can derive new hypertext relations. In (Weal et al., 2001) the open hypermedia structures are used as an interface to ontology browsing. The links at the user interface are transformed to queries over ontology. Thus links serves as contexts for particular user.

The question whether conceptual open hypermedia is the semantic web has been discussed in (Bechhofer et al., 2001). In (Carr et al., 2001) a *metadata space* is introduced, where the openness of systems and their use of metadata are compared. On the *metadata dimension* (x-axis), the units are the use of *keywords*, *thesauri*, *ontologies*, and *description logic*. The y-axis describes the *openness dimension* of systems starts from *CD ROM / file system, Internet*, *Web*, and ends with *Open* systems. Our approach can be seen as employing reasoning capabilities for Web-resources, or, concrete, to be on the crossings of description logic in the metadata dimension and Web in the openness dimension.

Adaptive hypermedia has been studied normally in closed worlds, i.e. the underlying document space / the hypermedia system has been known to the authors of the adaptive hypermedia system at design time of the system. As a consequence, changes to this document space can hardly be considered: A change to the document space normally requires the reorganization of the document space (or at least some of the documents in the document space). To open up this setting for dynamic document or information spaces, approaches for so called *open corpus adaptive hypermedia systems* have been discussed (Brusilovsky, 2001)(Henze and Nejdl, 2001) Our approach to bring adaptive hypermedia techniques to the web therefore contribute to the open corpus problem in AH. The relation of adaptive hypermedia and open hypermedia has for example been discussed in (Bailey et al., 2002).

In our approach, we use several ontologies for describing the features of *domains*, *users*, and *observations*. Compared to the components of adaptive hypermedia systems (Henze and Nejdl, 2003) ontology for adaptive functionality is missing. However, such ontology can be derived using the "updated taxonomy of adaptive hypermedia technologies" in (Brusilovsky, 2001). Reasoning over these distributed ontologies is enabled by the

RDF-querying and transformation language TRIPLE. Related approaches in the area of querying languages for the semantic web can be found, e.g., in (Bry and Schaffert, 2002). Here, a rule-based querying and transformation language for XML is proposed. A discussion of the interoperability between Logic programs and ontologies (coded in OWL or DAML+OIL) can be found in (Grosof et al., 2003).

Reasoning in open worlds like the semantic web is not fully explored yet, sharing and reusing of resources with high quality is still an open problem. In this paper, we discussed first ideas on the application of rules and rule-based querying and transformation language for the domains of open hypermedia and adaptive hypermedia.

Representation of Resources

Semantic web technologies like the Resource Description Format (RDF) (Lassila and Swick, 2002) or RDF schema (RDFS) (RDF, 2002) provide us with interesting possibilities. RDF schemas serve to define vocabularies for metadata records in an RDF file. RDF schemas can be used to describe resources, e.g. the RDF bindings of Learning Object Metadata (LOM) (Nilsson, 2001) can be used for these purposes, or RDF bindings of Dublin Core (Dublin Core, 2004). There is no restriction on the use of different schemas together in one RDF file or RDF model. The schema identification comes with attributes being used from that schema so backward dereferencing is again easily possible.

For example the RDF model of a lecture can use an attribute `subject` from Dublin Core Standard together with `isPartOf` from Dublin core metadata terms, etc. Part of an RDF-description for a course on Java programming can be seen in the following example. We have annotated the online version of the Sun Java tutorial (Campione and Walrath, 2000), which is a freely available online tutorial on Java programming.

```
<?xml version="1.0" encoding="iso-8859-1"?>

<rdf:RDF xml:lang="en"
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
xmlns:dc="http://purl.org/dc/elements/1.1/"
xmlns:dcterms="http://purl.org/dc/terms#">

<rdf:Description
rdf:about="http://java.sun.com/docs/books/tutorial/index.html">
   <rdf:type rdf:resource="http://ltsc.ieee.org/2002/09/lom-
educational#lecture"/>
   <dc:title>The Java Tutorial (SUN)</dc:title>
   <dc:description>A practical guide for programmers with hundreds of
      complete, working examples and dozens of trails - groups of lessons
      on a particular subject.
   </dc:description>
...
</rdf:Description>

<rdf:Description rdf:about="Object-Oriented_Programming_Concepts">
   <dc:title>Object-Oriented Programming Concepts</dc:title>
   <dcterms:isPartOf
rdf:resource="http://java.sun.com/docs/books/tutorial/index.html"/>
   <dcterms:hasPart>
      <rdf:Seq>
         <rdf:li rdf:resource="#What_Is_an_Object"/>
         <rdf:li rdf:resource="#What_Is_a_Message" />
         <rdf:li rdf:resource="#What_Is_a_Class"/>
         <rdf:li rdf:resource="#What_Is_Inheritance"/>
         <rdf:li rdf:resource="#What_Is_an_Interface"/>
         <rdf:li
rdf:resource="#How_Do_These_Concepts_Translate_into_Code"/>
         <rdf:li rdf:resource="#Questions_and_Exercises_Object-
Oriented_Concepts"/>
     </rdf:Seq>
```

```
   </dcterms:hasPart>
</rdf:Description>

....

<rdf:Description rdf:about="What_Is_an_Object">
   <dc:title>What Is an Object?</dc:title>
   <dc:description>An object is a software bundle of related variables
       and methods. Software objects are often used to model real-world
       objects you find in everyday life. </dc:description>
   <dc:language rdf:resource=
             "http://www.kbs.uni-hannover.de/~henze/lang.rdf#en"/>
   <dc:subject rdf:resource=
             "http://www.kbs.uni-hannover.de/~henze/java.rdf#OO_Objects"/>
   <dcterms:isPartOf rdf:resource="#Object-Oriented_Programming_Concepts"/>
</rdf:Description>

...

</rdf:RDF>
```

While RDF schema provides a simple ontology language, more powerful ontology languages, which reside on top of RDF and RDF schema, are available, too. For example, ontology languages like DAML+OIL (DAML+OIL, 2001) (the joint initiative of DAML (Darpa Agent Markup Language) and OIL (Ontology Inference Layer)) provide ontology layers on top of RDF / XML. Recently, OWL (OWL, 2003) (Web Ontology Language) has been developed, further enriching RDF.

An open question is how we can combine reasoning mechanisms on these (distributed) metadata and data resources, in order to generate hypertext presentations, link structures, etc., to bring the interoperability ideas from OHS to the WWW. This section will first describe semantic web tools that we employ in our approach, and then describe some structures for metadata components, which allow us to generate link structures according to user features.

Bringing together Resources and Reasoning

On top of the RDF and ontology-layer, we find the layer of logic in the semantic web tower, or, more recently, the layers of rules and logic framework (Berners-Lee, 2002). In our approach, the communication between reasoning rules and the open information environment will take place by exchanging RDF annotations: the rules reason over distributed RDF-annotations, results will be given back as RDF-files, too.

A rule language especially designed for querying and transforming RDF models is TRIPLE (Sintek and Decker, 2002). Rules defined in TRIPLE can reason about RDF-annotated information resources (required translation tools from RDF to triple and vice versa are provided).

TRIPLE supports *namespaces* by declaring them in clause-like constructs of the form *namespaceabbrev := namespace*, resources can use these namespaces abbreviations.

```
sun_java := "http://java.sun.com/docs/books/tutorial".
```

Statements are similar to F-Logic object syntax: An RDF statement (which is a triple) is written as `subject[predicate → object]`. Several statements with the same subject can be abbreviated in the following way:

```
sun_java:'index.html'[rdf:type->doc:Document;
  doc:hasDocumentType->doc:StudyMaterial].
```

RDF *models* are explicitly available in TRIPLE: Statements that are true in a specific model are written as "@model", e.g.

```
doc:OO_Class[rdf:type->doc:Concept]@results:simple.
```

Connectives and quantifiers for building logical formulae from statements are allowed as usual, i.e. ∧, ∨, ¬, ∀, ∃, etc. For TRIPLE programs in plain ASCII syntax, the symbols `AND`, `OR`, `NOT`, `FORALL`, `EXISTS`, `<-`, `->`, etc. are used. All variables must be introduced via quantifiers, therefore marking them is not necessary.

Domain Ontologies

First of all we need to determine domain ontologies. Domain ontologies comprise usually classes (classifies objects from a domain) and relationships between them. One possible domain in hypermedia application can be a domain of documents and concepts described in an application domain.

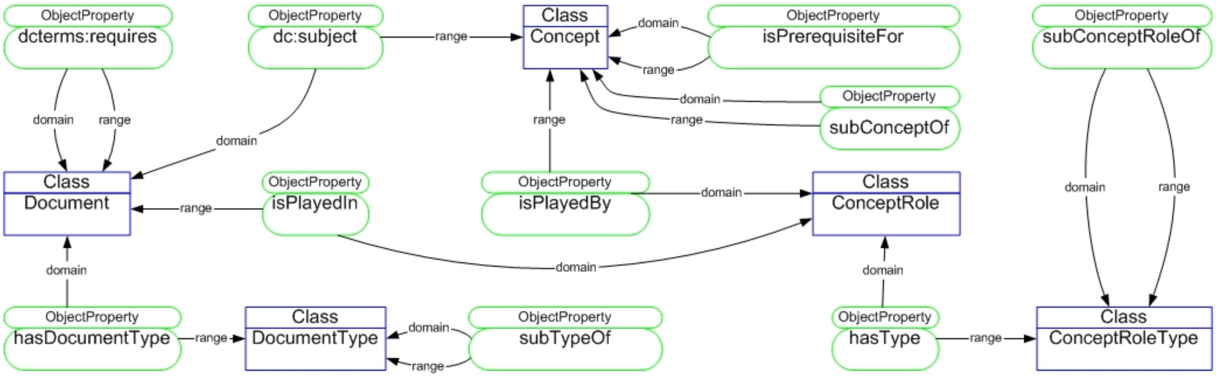

Figure 1. Ontology of documents

A simple ontology for documents and their relationships to other components is depicted in fig. 1. The class `Document` is used to annotate a resource, which is a document. Documents describe some concepts. We use class `Concept` to annotate concepts. Concepts and documents are related through `dc:subject` property. Documents can be ordered by `dcterms:requires` relationship. Concepts and documents have a certain role in their collaboration in certain document. We represent these facts by instances of `DocumentRole` class and its two properties: `isPlayedIn` and `isPlayedBy`. Concepts, document roles and concept roles can form hierarchies. We define `subRoleOf`, `subConceptRoleOf`, and `subConceptOf` properties for these purposes. Concepts play a certain role in a document. We recognize `Introduction` and `FullDescription` concept roles.

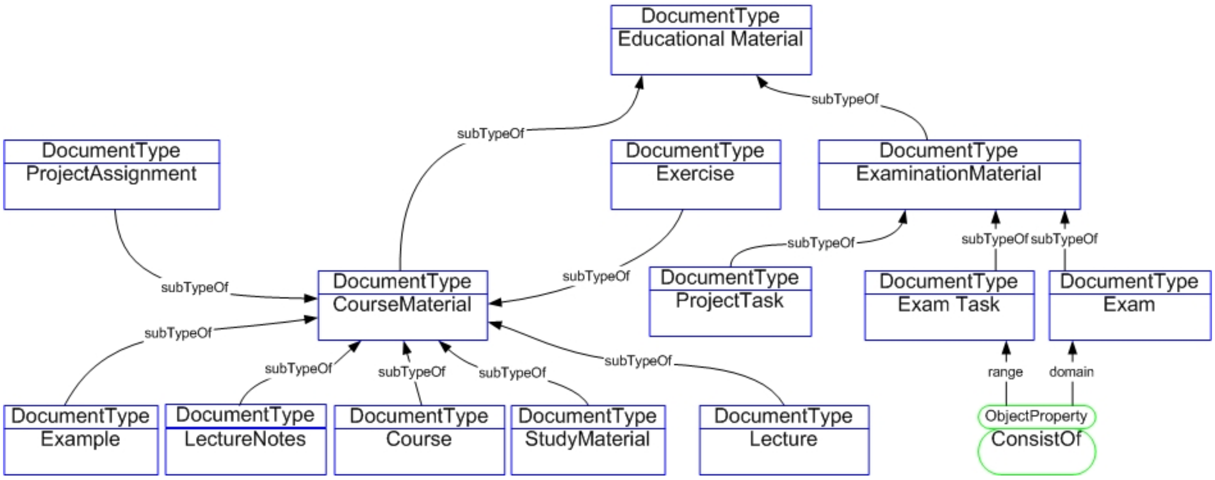

Figure 2. Ontology for documents types

Document can have a type. Figure 2 depicts the ontology with several document types for educational domain. The most general document type is `Educational Material`. `Educational Material` has two subtypes: `Course Material` and `Examination Material`. `Examination Material` can be further specialized to `Project Task`, `Exam Task`, and `Exam`. The `Exam` can consist of the `Exam Task`-s.

`Course Material` can be further specialized into `Lecture`, `Example`, `LectureNote`, `Course`, `Exercise`, and `Project Assignment`.

The document roles represent intended usage of the document in general. When a document is authored it is already known whether it will be a Lecture, Example and so on and it hardly fits to another role. Besides document roles, we recognize document types as well. Document types represent different context of a document. It means that we can differentiate at least between examination and study material. These are represented as separate document types `StudyMaterial` and `ExaminationMaterial`.

Figure 3 depicts `Programming_Strategies` concept with its subconcepts: `Object_Oriented`, `Imperative`, `Logical`, and `Functional`. `OO_Class`, `OO_Method`, `OO_Object`, `OO_Inheritance`, and `OO_Interface` are depicted as subconcepts of `Object_Oriented`.

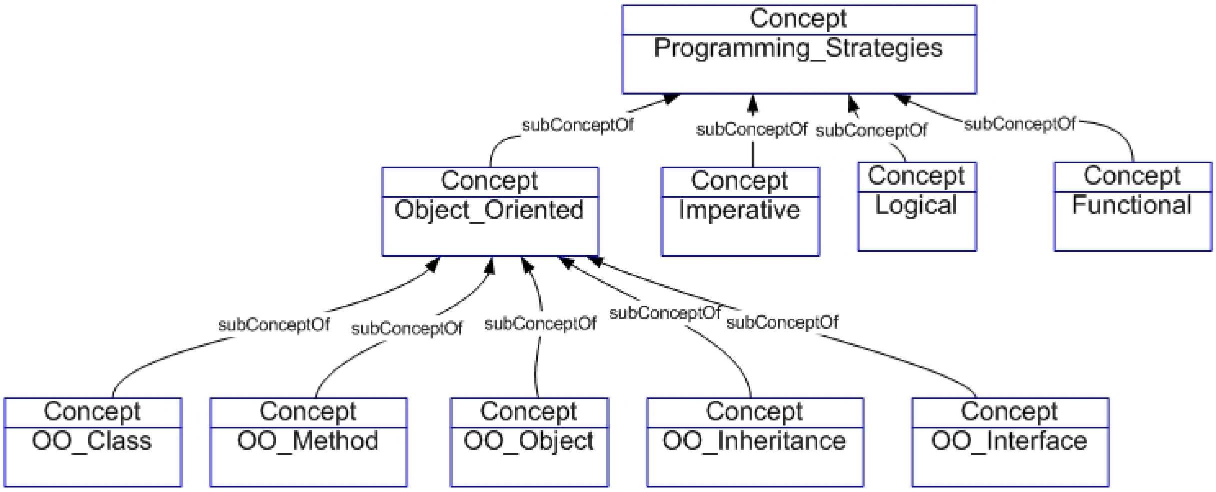

Figure 3. Concept ontology for Java e-lecture

Above described ontologies are used then in annotations of concrete documents/resources. An example of such resource can be a page describing sun_java:'java/concepts/class.html'. Following example shows how such a page can be annotated based on ontologies.

```
sun_java:'java/concepts/class.html'[
rdf:type->doc:Document;
dc:subject->doc:OO_Class].

doc:OO_Class[
rdf:type->doc:Concept;
doc:isPrerequisiteFor->doc:OO_Inheritance;
doc:subConceptOf->doc:Classes_and_objects].

doc:ClassesIntroduction[
rdf:type->doc:ConceptRole;
doc:isPlayedBy->doc:OO_Class;
doc:isPlayedIn->sun_java:'java/concepts/class.html';
doc:hasType->doc:Introduction].

doc:Introduction[
rdf:Type->doc:ConceptRoleType;
doc:subConceptRoleOf->doc:Cover].
```

The page is a document (RDF type `Document`). It describes information about classes. Thus it is annotated with `OO_Class` concept covered in the page. The `OO_Class` concept is annotated with type `Concept` and is subconcept of the `Classes_and_objects` concept. The `OO_Class` concept is prerequisite for the

OO_Inheritance. A page can have prerequisites. Then the dcterms:requires property can be used in the annotation.

The OO_Class concept plays a role of introduction in the sun_java:'java/concepts/class.html' document. This is annotated by ClassesIntroduction resource, which is of type ConceptRole. The reference to OO_Class concept and the document where it plays the introduction role is annotated by using properties isPlayedBy and isPlayedIn respectively. The role has type Introduction. The Introduction is of type ConceptRoleType and is subtype of Cover concept role type.

Users

Data about a user serves for deriving contextual structures. It is used to determine how to adapt the presentation of hypertext structures. Here we define ontology for a user profile based on IEEE Personal and Private Information (PAPI) (IEEE, 2000). PAPI distinguishes *personal*, *relations*, *security*, *preference*, *performance*, and *portfolio* information. The *personal* category contains information about names, contacts and addresses of a user. *Relations* category serves as a category for specifying relationships between users (e.g. classmate, teacherIs, teacherOf, instructorIs, instructorOf, belongsTo, belongsWith). *Security* aims to provide slots for credentials and access rights. *Preference* indicates the types of devices and objects, which the user is able to recognize. *Performance* is for storing information about measured performance of a user through learning material (i.e. what does a user know). *Portfolio* is for accessing previous experience of a user. Each category can be extended. For more discussion on learner modeling standards see for example (Dolog and Nejdl, 2003).

Figure 4 depicts an example of an ontology for a learner profile. The ontology is based on *performance* category of PAPI. We are storing sentences about a learner, which has a Performance. The Performance is based on learning experience (learningExperienceIdentifier), which is taken from particular document. The experience implies a Concept learned from the experience, which is maintained by learningCompetency property. The Performance is certified by a Certificate, which is issued by a certain Institution. The Performance has a certain PerformanceValue, which is in this context defined as a float number and restricted to interval from 0 to 1.

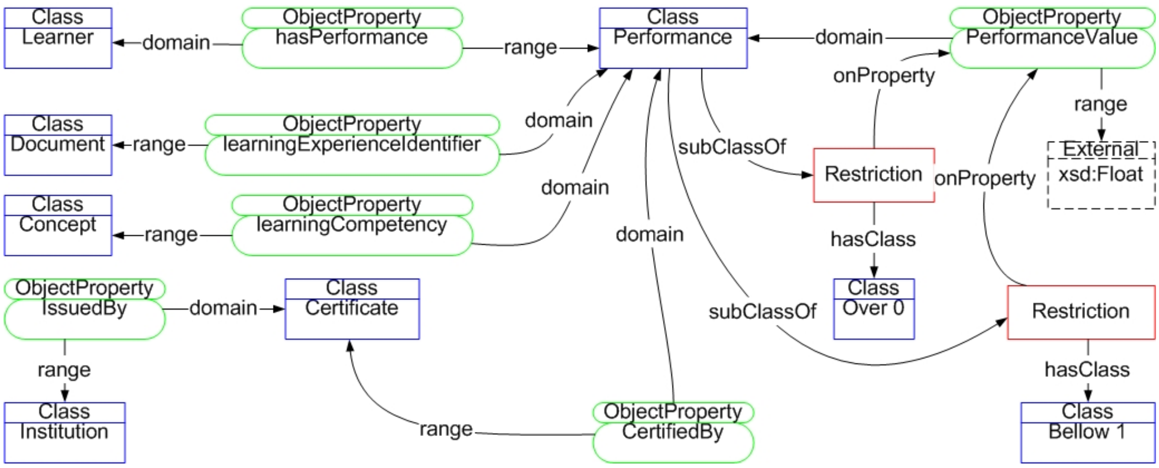

Figure 4. Ontology for learner performance

Another possibility to restrict the PerformanceValue is to define it with a range of LevelOf Knowledge. Then the instances of the class can be taken as measures of the learner performance.

The example of simple learner profile can look as follows.

```
user:user2[
  rdf:type -> learner:Learner;
  learner:hasPerformance -> user:user2P].

user:user2P[
  rdf:type->learner:Performance;
```

```
  learner:learningExperienceIdentifier-
>sun_java:'java/concepts/object.html';
  learner:learningCompetency->doc:OO_Object;
  learner:CertifiedBy->KBScerturi:C1X5TZ3;
  learner:PerformanceValue->0.9
].

KBScerturi:C1X5TZ3[
rdf:type->learner:Certificate;
learner:IssuedBy->KBSuri:KBS
].

KBSuri:KBS[
rdf:type->learner:Institution
].
```

The learner `user2` has the performance (`user2P`) record. The performance contains a learning experience about the KBS Java objects resource. The concept covered in the resource is stored in the performance as well. Then a certificate about the performance with performance value and institution that issued the certificate is recorded into the learner performance as well.

Observations

During runtime, users interact with a hypertext system. The user's interactions can be used to draw conclusions about possible user interests, about user's goal, user's task, user's knowledge, etc. These concluded user features could, as described in the previous section, be used for providing personalized views on hypertexts. An ontology of observations should therefore provide a structure of information about possible user observations, and - if applicable - their relations and/or dependencies.

A simple ontology for observations is depicted in fig. 5. The ontology allows us to instantiate facts that a `Learner` has interacted with (`hasInteraction` property) with a particular `Document` (`isAbout` property) via an interaction of a specific type (`InteractionType`). The interaction has taken place in a time interval between `beginTime` and `endTime`, and has a certain level (`Level`) associated, the `ObservationLevel`. Several events (see next section) can contribute to an interaction. Example of `InteractionTypes` are of kind `access`, `bookmark`, `annotate`, examples for ObservationLevels are that a user has `visited` a page, has `worked` on a project, has `solved` some exercise, etc.

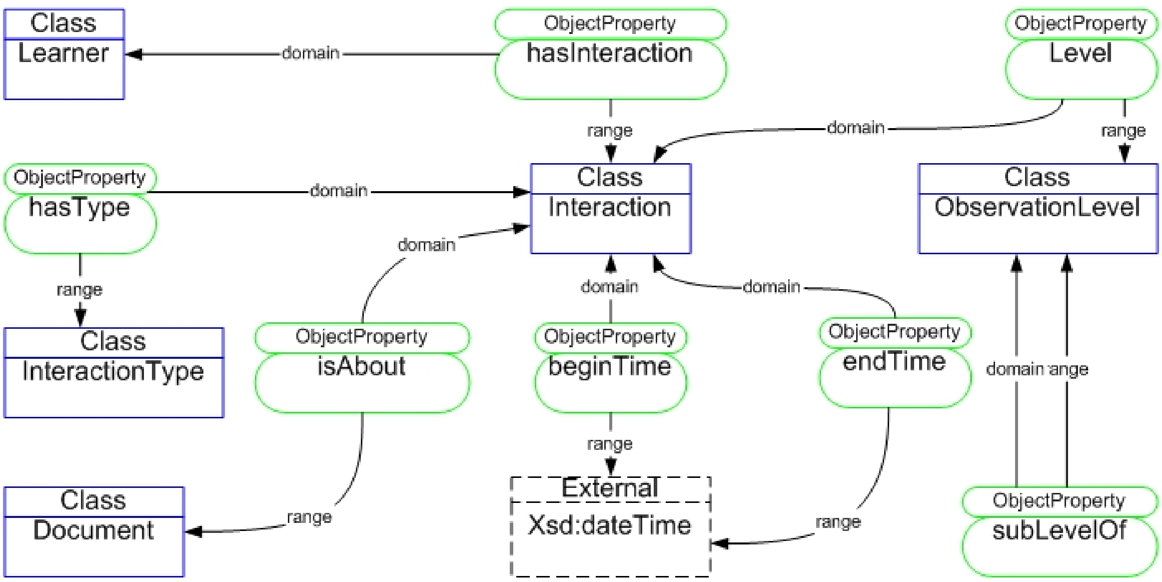

Figure 5. Ontology for observations

Generating Hypertext Structures

Hypertext structures as described in several works on open hypermedia (see e.g Millard et al., 2000) can be generated from metadata reported in the previous section. We do not store the hypertext structures on servers as first class entities but we allow generating such structures on the fly. In order to generate such hypertext structures we need ontology for structures. Then transformation rules can be used to generate instances of that structure.

Presentation Ontology

Presentation ontology is used for describing structure relevant for visualization. Such an ontology adapted from FOHM (Millard et al., 2000) is depicted in Figure 6.

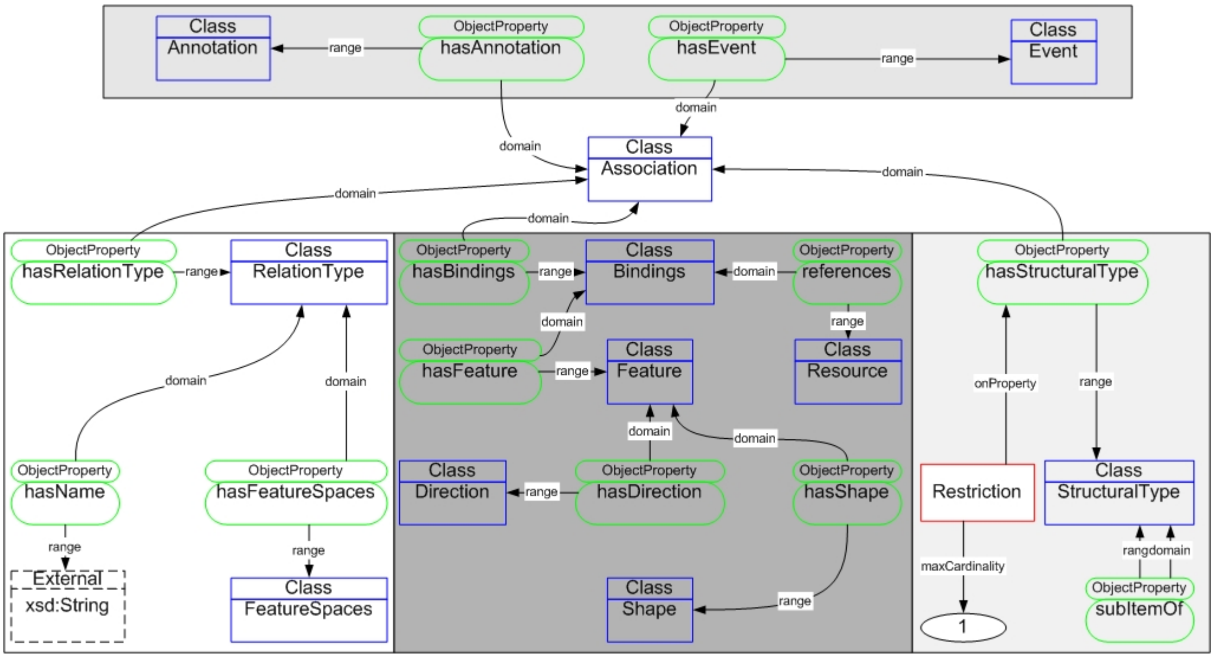

Figure 6. A part of presentation ontology

The main element of the ontology is the `Association`. Like in (Millard et al., 2000), the `Association` is built from three components: `Bindings`, `RelationType`, and `StructuralType` (in FOHM they refer to it as Cartesian product of bindings, relation type and structural type). These three components (classes) are related to association through `hasBindings`, `hasRelationType`, and `hasStructuralType` properties.

`Bindings` references a particular `Resource` on the web (document, another association, etc.), and `Feature`-s. A `Feature` can be a `Direction`, `Shape`, etc. Entries for `Direction` are depicted in figure 7b, entries for `Shape` are depicted in the figure 7c.

The `RelationType` has a `Name` that is a string. The `RelationType` also points to the `FeatureSpaces`. Entries for the `FeatureSpaces` are depicted in Figure 7a. A `StructuralType` is one of stack, link, bag, or sequence of resources.

In addition, `Association` can have associated events (e.g. click events for processing user interactions) through `hasEvent` property, and an annotation (e.g. green/red/yellow icon from traffic light metaphor technique from adaptive hypermedia) through `hasAnnotation` property.

The `hasEvent` property defines an event, which is provided within the document (to be able to get appropriate observation). Whenever the event is generated observation-reasoning rules assigned to this type of event are triggered. The `represents` property references a resource, which is stored in observations about learner, after an event is generated as well.

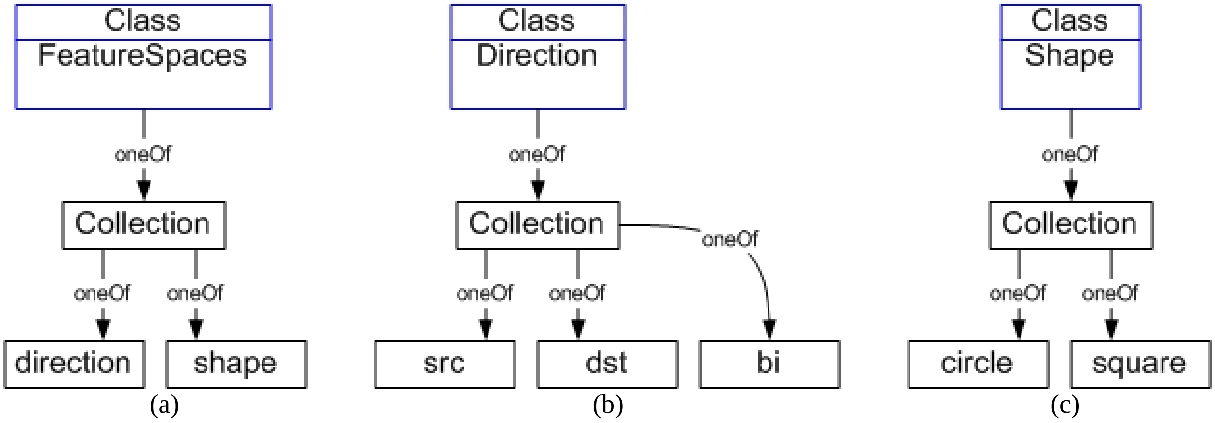

Figure 7. Members of Collection of: (a) Feature Spaces, (b) Direction, (c) Shape.

FOHM introduces *context* and *behavior* objects. Filtering and contextual restrictions maintained by the *context* objects in FOHM are substituted by more richer reasoning language and rules in our approach. On the other hand, interactions and observations together with events substitute the notion of *behavior* objects.

Reasoning Rules

In this chapter we show how rules are employed to reason over distributed information sources (ontologies, user profile information, resource descriptions). The communication between reasoning rules and the open information environment will take place by exchanging RDF annotations (RDF, 2002). Rules are encoded in the TRIPLE rule language (see section 3.1). For further examples on adaptation rules we refer the reader to (Dolog et al., 2003).

In the following, we provide a set of rules that can be used to construct an *example*-relation between resources. Assume a user `U` is visiting some page `D`. An example, illustrating the content of this page, can be found by comparing the concepts explained on the current page with the concepts shown on an example page. Several grades of how good an example is can be derived.

The easiest way for deriving an example-relation to a page `D` is by ensuring that each concept on `D` is covered by the example `E`:

```
FORALL D, E example(D,E) <-
    studyMaterial(D) AND example(E) AND
    EXISTS C1 (D[dc:subject->C1]) AND
    FORALL C2 (D[dc:subject->C2] -> E[dc:subject->C2]).
```

The second line in the rule above ensures that `D` is `StudyMaterial` and `E` is an `Example` (according to the ontology of documents "docs"). The third rule is verifying that `D` really is about some measurable concept - thus there exists a metadata annotation like `dc:subject`. The fourth line then really expresses what our rule should check: Whether each concept on `D` will be explained in the example `E`.

Another possibility is to provide relations to examples that cover exactly the same concepts as a page `D`:

```
FORALL D, E exact_example(D,E) <-
    studyMaterial(D) AND example(E) AND
    EXISTS C1 (D[dc:subject->C1]) AND
    FORALL C1 (D[dc:subject->C1] -> E[dc:subject->C1]) AND
    FORALL C2 (E[dc:subject->C2] -> D[dc:subject->C2]).
```

The second and third lines in this rule are the same as in the previous rule. The fourth and fifth line ensures that each concept on `D` is covered on `E` and vice versa.

If we want to show examples, which might illustrate only some aspects of a page `D`, we can derive relations to *weaker* examples by

```
FORALL D, E weaker_example(D,E) <-
    studyMaterial(D) AND example(E) AND
    EXISTS C (D[dc:subject->C] AND E[dc:subject->C]).
```

Which is be valid whenever at least on concept explained on `D` is part of the example `E`.

From the area of adaptive hypermedia, several methods and techniques have been provided to adapt the navigation and / or the content of a hyperspace to the needs, preferences, goals, etc. of each individual user. In (Henze and Nejdl, 2003) we have provided a logical characterization of adaptive educational hypermedia based on First Order Logic (FOL). There, an adaptive educational hypermedia system is described in FOL as a quadruple consisting of a *document space* - a hypermedia system which document nodes and their relations, a *user model* for modelling and inferencing on various individual characteristics of a user, an *observation component* which is responsible for monitoring a user's interaction with the system, and an *adaptation component* which consists of rules which describe adaptive functionality. A way to implement open adaptive hypermedia system is shown in (Dolog et al., 2003). In this paper, we will use adaptive hypermedia to provide personalized associations. We can think of a personalized *pedagogical* recommendation of examples: The best example is an example that shows the new things to learn in context of already known / learned concepts: This would embed the concepts to learn in the previous learning experience of a user. The rule for derive this *best_example* is as follows:

```
FORALL D, E, U best_example(D,E,U) <-
    studyMaterial(D) AND example(E) AND user(U) AND example(D,E) AND
    FORALL C ( (E[dc:subject->C] AND NOT D[dc:subject->C]) ->
           p_obs(C, U, Learned) ).
```

The rule for determining whether a user has learned some concept `C (p_obs(C, U, Learned)` is derived by checking the characteristics of the user profile. A concept is assumed to be learned if we find a `Performance` of this user via the user profile, which is related to the concept in question.

```
FORALL C, U  p_obs(C, U, Learned) <- user(U) AND concept(C) AND
    EXISTS P (U[learner:hasPerformance->P] AND user_performance(P) AND
    P[learner:learningCompetency->C]).
```

The results of these rules (on the RDF-annotated and to triple translated resources provided in the Appendix) are e.g. that a page on "objects in Java (object.html)" can be related to pages, which show "concepts of object orientation in Java (practical.html)" or "objects and methods in Java (objects_methods.html)". Using the general “example” -rule derives these relations:

```
D = sun_java:'java/concepts/object.html', E =
sun_java:'java/concepts/practical.html'
D = sun_java:'java/concepts/object.html', E =
kbs_java:'java_script/examples/objects_methods.html'
```

The "exact_example-rule" from above derives for this data set that only the "overview on object-orientation in Java (OO_overview.html)" has an exact matching example.

```
D = kbs_java:'java_script/concepts/OO_overview.html',
E = sun_java:'java/concepts/practical.html'
```

The "weaker_example-rule" suggests the same example page (practical.html), which exactly fits to the document OO_overview.html also to pages about only some aspects like "methods in Java (message.html).

```
D = sun_java:'java/concepts/message.html',
E = sun_java:'java/concepts/practical.html'
```

The "best_example" for a user who is currently visiting a page on "methods in Java (message.html)" and who has already knowledge about "objects in java" is an example illustrating these two concepts (object_methods.html). In the data set provided in the appendix, user2 is currently in this position.

```
D = sun_java:'java/concepts/message.html',
E = kbs_java:'java_script/examples/objects_methods.html',
U = user:user2
```

Further rules for generating personalized hypertext associations can be used by more extensive use of facts from domain, user, and observation ontology. E.g. the mentioned `subConceptOf` relationship in the concept-ontology of the java application domain can be for example utilized to recommend either more general documents introducing a concept of programming strategies in general, or to recommend more specific documents (resources) about object oriented programming strategy based on requirements, level of knowledge, or interest of a user.

Sequencing relationship is another relationship that can be used to recommend documents. A document (resource) which describes a concept (the concept appears in `dc:subject` slot in metadata about the document) from the beginning of the sequence will be recommended sooner than a document which describes a concept from the end of such a sequence.

A dependency relationship referring to whether a concept depends on another concept can be used as well. It can be used to recommend documents, which describe dependent concepts together with a document describing a concept that was recommended by another rule.

Conclusion and Further Work

In this paper, we have proposed an approach for dynamically generating personalized hypertext relations powered by reasoning mechanisms over distributed RDF annotations. We have shown an example set of reasoning rules that decide for personalized relations to example pages given some page. Several ontologies have been used which correspond to the components of an adaptive hypermedia system: a domain ontology (describing the document space, the relations of documents, and concepts covered in the domain of this document space), a user ontology (describing learner characteristics), and an observation ontology (modelling different possible interactions of a user with the hypertext). For generating hypertext structures, presentation ontology has been introduced. We have been developing a demonstrator system showing the realization of the formalisms we presented in this paper. This demonstrator, the *Personal Reader* (Dolog et al., 2004a), generates a personalized conceptual context of learning resources. This context is generated by using adaptation rules like those presented in this paper, and integrates this technology with a personalized search facility (Dolog et al., 2004b).

In further work, we plan to extend our demonstrator, and to investigate how to employ further ontologies like ontology for educational models. This will enable us to add additional rules to enhance adaptive functionality based on the facts modelled in the knowledge base by utilizing additional relationships.

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Appendix: Set of Rules for Deriving Relations between Information Pages and Examples

```
daml  := "http://www.daml.org/.../daml+oil#".
rdf   := "http://www.w3.org/1999/02/22-rdf-syntax-ns#".
doc   := "http://www.example.org/doc#".
results := "http://www.results.org/results#".
sun_java := "http://java.sun.com/docs/books/tutorial/".
kbs_java := "http://www.kbs.uni-hannover.de/".
java := "http://www.kbs.uni-hannover.de/~henze/java.rdf#".

@results:data{
sun_java:'index.html'[rdf:type->doc:Document;
  doc:hasDocumentType->doc:StudyMaterial].
sun_java:'java/index.html'[rdf:type->doc:Document;
  doc:hasDocumentType->doc:StudyMaterial].
sun_java:'java/concepts/index.html'[rdf:type->doc:Document;
  doc:hasDocumentType->doc:StudyMaterial].
sun_java:'java/concepts/object.html'[rdf:type->doc:Document;
  doc:hasDocumentType->doc:StudyMaterial;
  dc:subject->java:'OO_Object'].
sun_java:'java/concepts/message.html'[rdf:type->doc:Document;
  doc:hasDocumentType->doc:StudyMaterial;
  dc:subject->java:'OO_Method'].
sun_java:'java/concepts/class.html'[rdf:type->doc:Document;
  doc:hasDocumentType->doc:StudyMaterial;
  dc:subject->java:'OO_Class'].
sun_java:'java/concepts/inheritance.html'[rdf:type->doc:Document;
  doc:hasDocumentType->doc:StudyMaterial;
  dc:subject->java:'OO_Inheritance'].
sun_java:'java/concepts/interface.html'[rdf:type->doc:Document;
  doc:hasDocumentType->doc:StudyMaterial;
  dc:subject->java:'OO_Interface'].
sun_java:'java/concepts/practical.html'[rdf:type->doc:Document;
  doc:hasDocumentType->doc:Example;
  dc:subject->java:'OO_Object';
  dc:subject->java:'OO_Method';
  dc:subject->java:'OO_Class';
  dc:subject->java:'OO_Inheritance';
  dc:subject->java:'OO_Interface'].

kbs_java:'java_script/examples/objects_methods.html'[rdf:type->doc:Document;
  doc:hasDocumentType->doc:Example;
  dc:subject->java:'OO_Object';
  dc:subject->java:'OO_Method'].
kbs_java:'java_script/concepts/OO_overview.html'[rdf:type->doc:Document;
  doc:hasDocumentType->doc:StudyMaterial;
  dc:subject->java:'OO_Object';
  dc:subject->java:'OO_Method';
  dc:subject->java:'OO_Class';
  dc:subject->java:'OO_Inheritance';
  dc:subject->java:'OO_Interface'].

java:'OO_Object'[rdf:type->doc:Concept;
  doc:isPrerequisiteFor->java:'OO_Method'].

java:'OO_Method'[rdf:type->doc:Concept;
  doc:isPrerequisiteFor->java:'OO_Class'].

java:'OO_Class'[rdf:type->doc:Concept;
  doc:isPrerequisiteFor->java:'OO_Inheritance'].

java:'OO_Inheritance'[rdf:type->doc:Concept;
  doc:isPrerequisiteFor->java:'OO_Interface'].

user:user1[
  rdf:type -> learner:Learner;
  learner:hasPerformance -> user:user1P].
```

```
user:user1P[
  rdf:type->learner:Performance].

user:user2[
  rdf:type -> learner:Learner;
  learner:hasPerformance -> user:user2P].

user:user2P[
  rdf:type->learner:Performance;
  learner:learningCompetency -> java:'OO_Object'].
}

@results:simple{

  FORALL O,P,V O[P->V] <-
    O[P->V]@results:data.

  FORALL D document(D) <- D[rdf:type->doc:Document].
  FORALL C concept(C) <- C[rdf:type->doc:Concept].
  FORALL U user(U) <- U[rdf:type->learner:Learner].
  FORALL P user_performance(P) <- P[rdf:type->learner:Performance].
  FORALL E example(E) <- document(E) AND
          E[doc:hasDocumentType->doc:Example].
  FORALL E studyMaterial(E) <- document(E) AND
          E[doc:hasDocumentType->doc:StudyMaterial].

  FORALL C, U  p_obs(C, U, Learned) <- user(U) AND concept(C) AND
    EXISTS P (U[learner:hasPerformance->P] AND user_performance(P) AND
    P[learner:learningCompetency->C]).

  FORALL D, E example(D,E) <-
    studyMaterial(D) AND example(E) AND
    EXISTS C1 (D[dc:subject->C1]) AND
    FORALL C2 (D[dc:subject->C2] -> E[dc:subject->C2]).

  FORALL D, E exact_example(D,E) <-
    studyMaterial(D) AND example(E) AND
    EXISTS C1 (D[dc:subject->C1]) AND
    FORALL C1 (D[dc:subject->C1] -> E[dc:subject->C1]) AND
    FORALL C2 (E[dc:subject->C2] -> D[dc:subject->C2]).

  FORALL D, E weaker_example(D,E) <-
    studyMaterial(D) AND example(E) AND
    EXISTS C (D[dc:subject->C] AND E[dc:subject->C]).

  FORALL D, E, U best_example(D,E,U) <-
    studyMaterial(D) AND example(E) AND user(U) AND example(D,E) AND
    FORALL C ( (E[dc:subject->C] AND NOT D[dc:subject->C]) ->
           p_obs(C, U, Learned) ).

}

/* Several Views */
FORALL D, E <- example(D, E)@results:simple.
FORALL D, E <- exact_example(D, E)@results:simple.
FORALL D, E <- weaker_example(D, E)@results:simple.
FORALL D, E, U <- best_example(D, E, U)@results:simple.
```

Abel, M.-H., Benayache, A., Lenne, D., Moulin, C., Barry, C., & Chaput, B. (2004). Ontology-based Organizational Memory for e-learning. *Educational Technology & Society*, 7 (4), 98-111.

Ontology-based Organizational Memory for e-learning

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Abstract

e-learning leads to evolutions in the way of designing a course. Diffused through the web, the course content cannot be the direct transcription of a face to face course content. A course can be seen as an organization in which different actors are involved. These actors produce documents, information and knowledge that they often share. We present in this paper an ontology-based document-driven memory which is particularly adapted to an e-learning situation. The utility of a shared memory is reinforced in this kind of situation, because the interactions do not usually occur in the same place and in the same time. First we precise our conception of e-learning and we analyze actors needs. Then we present the main features of our learning organizational memory and we focus on the ontologies on which it is based. We consider two kinds of ontologies: the first one is generic and concerns the domain of training; the second one is related to the application domain and is specific to a particular training program. We present our approach for building these ontologies and we show how they can be merged. Finally we describe the learning memory and the prototype we realized for two course units proposed in our universities.

Keywords

E-learning, Ontology, Organizational memory, Topic maps.

Introduction

Information Technology has already transformed the way people work and has an increasing impact on the long life learning. New approaches mainly based on the utilization of web technologies are proposed. They often refer to the concept of “e-learning”. Unfortunately, the term e-learning is used to designate various types of situations such as administrative course management, web-based learning, or videoconferences. Usual e-learning definitions put the emphasis more on network utilization and pedagogical content than on distribution of courses. Numerous documents resources may be used during e-learning. Some are internal and made by several actors implied in the e-learning. Others are available on the web: on-line courses, course supports, slides, bibliographies, frequently asked questions, lecture notes, etc. The increasing number of available resources is a real problem in content management systems.

Research work on the Semantic Web aims at addressing this kind of problem. The Semantic Web is an extension of the current web in which information is given well-defined meaning, enabling computers and people to better work in co-operation (Berners-Lee et al., 2001). The idea is to represent web data, to define and link them so that they can be used for more effective discovery, automation, integration, and reuse across various applications. The Web can reach its full potential if it becomes a place where data can be shared and processed by automated tools as well as people. Sharing data is one of the basic principles the Semantic Web will operate on. In order to be able to exchange the semantics of information, one first needs to agree on how to explicitly model it. Ontologies are a way of representing such formal and shared information. They can be used to index data indicating their meaning, thereby making their semantics explicit and machine-accessible.

In the MEMORAe project, which relates to this research field, we propose to consider an e-learning training as an organization and to manage the resources of this organization by the means of an ontology-based “learning organizational memory” (Abel, Lenne, & Cissé, 2002). This memory allows, on one hand, to capitalize the learning knowledge, and on the other hand, to better index resources, taking into account the learning context. The MEMORAe project (that stands in French for Organizational Memory Dedicated to e-learning) is supported by STEF, a research pole of the French Picardie region.

In this paper, we first present our conception of e-learning thanks to a scenario of use. Then we introduce the notion of "learning organizational memory". This notion requires specific ontologies that allow to organize knowledge element and index resources. We introduce two application ontologies about algorithms and statistics. They are originally based on the experience of two courses: "Algorithms and Programming Pascal" (NF01) and "Statistics" (B31.1), respectively taught at the French universities of Compiègne and Amiens. Building such ontologies is a hard work and we propose to illustrate the method we followed to build them. Then, we show that it is necessary to merge an application ontology into a domain ontology and the way it is concretely possible. Finally, we illustrate the use of the memory through a prototype we have developed and still maintain.

e-learning

Our conception of e-learning

The term ‘e-learning’ is currently very used and refers to various notions such as logistic (administrative management), resources (course broadcasting) or technology (virtual conference tools). Numerous definitions of e-learning have been proposed. They usually put the emphasis on network utilization (explaining the « e » in e-learning) and on Information Technology. E-learning must not be reduced to the use of new technologies to serve old learning modes. It is supposed to lead to new learning forms. This implies some consequences. For example, e-learning needs at least:

- A reflection on the content: goals, concepts to study, competences to acquire, etc.
- A reflection on the content organization: relations between learning concepts,
- A construction of new resources taking into account possibilities offered by Information Technology: direct digitalization of old resources is not sufficient,
- A redefinition of actors (teachers, learners) roles.

Within the MEMORAe project, we are interested in the building of a pedagogical content under a granular form represented by ontology of concepts. Users must have free access to this ontology. Indeed, we consider that the learner must have an active role in his learning. Available documents are not simply transcription of classical courses. They consist in a set of resources that intend to be easy-to-access because of their indexation by the ontology of learning domain concepts. The courses we deal with are scientific courses taught at university.

Use scenario

In our conception of e-learning, knowledge and information structuring is central as well for learners as for teachers. The ontology-based organizational memory we propose aims at helping them to structure and manage knowledge related to a given course or training unit. It relies on an organization model of this course unit and takes into account teachers and learners viewpoints.

In an e-learning situation, learners are often geographically distant. It is thus necessary for them to have an easy access to documents and more generally to resources they need. But because of the distance, they often need to get into contact and to dialogue with teachers and with other learners. Furthermore, certain types of activities (such as practical work) explicitly require cooperation between students.

During training, learners are often led to ask questions regarding the content of a course. For example: What are the goals of this lesson? What are the notions to be learnt? What are the prerequisites? Is there any order in these notions? Are there any documents to consult (slides, books, etc.)? What is it possible to do in order to improve a lesson? Is there any web site, newsgroup dealing with this lesson? Etc.

During training, students have often to produce documents that are sent to teachers for evaluation or that are kept. In this last case, documents can be for example work or synthesis documents or annotations (Marshall, 1998). The students can decide (or propose) later to make these documents available for other users. It is therefore useful to allow the attribution of different grants to documents.

The definition of a shared vocabulary is a key point in order to facilitate access to documents, dialogue with teachers and collaboration with other learners.

Learning organizational memory

A course unit is based on knowledge and competencies it should provide, on actors (learners, instructors, trainers, course designers, administrators, etc.) and on resources of different types (definitions, exercises with or without solution, case studies, etc.), and different forms (reports, books, web sites, etc.). In this sense, a course is an organization.

A common approach to tackle the knowledge management problem in an organization consists in designing an organizational memory. Such a memory can be seen as "an explicit and persistent representation of knowledge and information in an organization, in order to facilitate their access and reuse by members of the organization for their tasks" (Rabarijaona et al., 2000).

An organizational memory allows capitalizing not only pedagogical resources related to the contents of the course but also information on actors themselves (specificities, background, profile, etc.). It allows administrative management (registration, notes, etc.) of the course too.

In order to share information in an organization, actors have to use a common terminology, especially when they are geographically distant. A given word or expression must have the same meaning for everyone. It is one of the reasons why organizational memories are often based on ontologies.

Organizational Memories and Learning Organizational Memories

A learning organizational memory is different from an organizational memory because of its goal, which is to provide users with content and more precisely pedagogical content. This pedagogical content is composed of the notions to acquire, the links between these notions and the resources they index.

Notions are not only chosen because they are related to the course unit, they are also the result of a reflection on the course itself. A pedagogical work has to be done. For example, with NF01, why and how to make a link between the "loop" and "array" notions?

Resources have to be selected relying on pedagogical goals. The choice of their indexation terms is related to this goal too. It is not an automatic indexation. The course manager (with the help of an editorial committee if needed) is responsible for the pertinence of the links. It is not because a document treats of a notion to acquire that it will be necessary indexed by this notion. The choice is explicit, that is to say that the document must have been evaluated as sufficiently adapted to the learning of this notion.

These choices are part of the pedagogical scenario the course manager wants to implement. In a classical organizational memory, there is no pedagogical scenario because the objective of this kind of memory is not training.

The learning organizational memory we propose aims at facilitating knowledge organization and management for a given course or training, and at clarifying competencies it allows to acquire.

Pedagogical content of a learning OM

The pedagogical content of a learning organizational memory is mainly composed of the notions to learn, the links relating them and the documents indexed by them. The manager of a training memory is responsible for its content, that is to say the choice of the notions to learn and the documents indexed by these notions. In this sense there is no course design (as it can exist in a linear course), but more precisely pedagogical content selection. We precise below what are "notions to learn" for us, then we present different kind of pedagogical resources and our conception of annotations.

Notion to learn

The design of an e-learning application implies to focus on the learner, giving him/her the means to be active, to make him/her understand the resources that are at his/her disposal and to teach him/her how to search and to use them. Articulating a course starting from knowledge grains offers more individualization possibilities. For some authors (Boullier, 2001), it consists in dividing the course content in fine grains, using a semantic mark-up.

On the contrary, we do not use the expression 'notion to learn' to refer to a course unit part, but to a notion to acquire. Consequently, there is no need to cut off existing documents or to produce new documents corresponding to these notions. Authors remain free regarding the making of their documents. They do not have to follow graphical or contents guidelines. Moreover they can reuse existing documents.

Notions to learn (i.e. fine grains) are used as indexes to access documents related to them. A notion to learn can refer to several documents (giving several means to acquire it) and a document can be referred to by several notions (giving several means to retrieve it).

Note that a digital document can be already made of several parts that can be themselves indexed. It will however remain a document as a whole for which the author has no writing guidelines to follow. Furthermore another logical partition of this document can be done by the author or the editorial committee later.

Pedagogical resources

Pedagogical resources are generally documents: course texts, course notes, slides, e-books, reports, books presentations, links to web sites … Among the represented documents, some (digital documents) are stored in the memory and others are references to physical documents.

Resources can be accessed according to different rights. They can be private. In this case, users only store them in the memory and do not want to give other users access to them. They can be annotations, work in progress, downloaded and not yet analyzed documents … Resources can also be semi-public or public, that is to say shared by part or all of the users. For example, an annotation of a reader giving his/her motivated impression on a document can help memory users to choose appropriate documents. Moreover, several annotations written by different authors or relying on different notions can be attached to a same document.

Resources can also have different status. They can be terminated and validated documents, or on the contrary, working documents written by one or more users and therefore shared by them during the time of their realization.

Annotations

Our reflection on annotations started from two observations:

- On one hand, when users of the memory access a notion to acquire, there are faced with several resources related to this notion. The choice can be based, as it is presently, on several associated characteristics: author, resource type (book, web site, etc) but it could be guided by other information such as comments or remarks on the resources.
- On the other hand, the role of an organizational memory is to capitalize knowledge. It is then useful to keep track of the reasons that led a course manager to choose a resource, a notion, or a link between two notions.

We propose to take into account this information by using annotations. (Marshall, 98) identified different dimensions allowing to characterize different approaches of annotations:

- Formal vs. informal annotations. Examples of formal annotations are metadata, specifically metadata that follows structural standards and are assigned values using conventional authorities.
- Explicit vs. tacit annotations. Many personal annotations, by their nature, are telegraphic, incomplete, and tacit. On the other hand, annotations written for others are usually more explicit.
- ·Permanent vs. transient annotations. Annotations may not be permanent. If annotations are reflections of a reader's engagement in the text, their value may only hold for the current traversal through the narrative or hyper narrative. On the other hand, some annotations have been observed to bring value to future readers.
- Published vs. private. We all know of circumstances in which annotations are private form. On the other hand, annotated editions of important scholarly works are a good example of published commentary.

In the Memorae project we consider that an annotation:

- Is a resource, result of an annotation action.
- Is related to a target that can be a notion to learn (concept), a link between concepts, a resource, a part of resource, a collection of resources.
- Has one or several authors and presents its/their comments on the target. These comments are created at a given date, with a precise objective, and are directed to a precise audience (that can be the author himself in case of a personal annotation).
- Is not part of the target itself. It is then necessary to make a link between the target and the annotation.
- Makes sense only in its context (target, author, goal, audience).
- Can be text, graphic, voice or illustration.

Note that a target must have a representation in the memory, in order to be annotated. As an annotation is a resource, it can be itself annotated. Following this conception our notions to learn are not annotations, they are metadata. We will now see how we represent them using ontologies.

Ontologies

Ontologies for e-learning

For navigating through the memory, the end-users (learners, teachers, etc.) need a shared vocabulary. That is why we decided to model the memory with ontologies. From the different ontology types defined by Van Heijst (Van Heijst, 1997), generic ontologies, domain ontologies, application ontologies and meta-ontologies, we only use the second and third categories. We have to consider two aspects for modeling the memory and building ontologies (Breuker et al., 1999). First the domain of training has its own characteristics. Secondly, it must be linked to the application domain of a particular training program. According to Gruber (Gruber, 1995) "An ontology is an explicit specification of a conceptualization". Guarino gives a precision on this definition, considering that ontologies are necessarily a partial specification of a conceptualization (Guarino, 1995). We can add with Gruber "an ontology is a description (like a formal specification of a program) of the concepts and relationships that can exist for an agent or a community of agents".

The first ontology (domain ontology) we have to specify, describes the concepts of the « training » domain. They can be users types (tutor, secretary), documents types (book, slides for oral presentation, web page, site, etc.), media types (text, image, audio, video). They can also be pedagogical characteristics (activity type) and they can refer to point of view (annotation). It is difficult to directly reuse part or a whole of existing ontologies because they mainly depend on objectives and choices for specific needs, but we must consider the help they can bring.

We studied pedagogical ontologies like the one presented in (Chabert-Ranwez, 2000). It deeply describes types of tests as multiple choice, true false, or matching. It is also possible to find activity types description in (Desmoulins & Mille, 2002). Pedagogical resources are not organized following the way recommended by the Learning Object Metadata standard in the Educational Category, because we do not agree to associate various activity types like exercise or simulation, with data representation like diagram, figure or graph in the same set. A description of the LOM standard can be found in the document 1484.12.1, http://ltsc.ieee.org/wg12/index.html.

The second ontology (application ontology) specifies the organization of theoretical notions that are studied during training session. In the example of an initiation to algorithmic, some notions like data structure or control structure are explained. It is possible, but not mandatory, to consider "tree" and "array" as sub-concepts of the concept “data structure” and to define the relation “uses” between the concepts “data structure” and “iterative structures” (in this case they are the domain and range value of this relation).

These ontologies are not independent; the second one is necessarily attached to the first one. For example, to express that a document is an introduction to data structures we join the two concepts “introduction” and “data structures” that do not belong to the same ontology. Pedagogical relations like “prerequisite” or “uses” that occur between concepts of the application ontology are defined in the domain ontology. However, specific roles can belong to the application ontology (for example for the B31.1 application, “has a cardinality”).

Integration of ontologies

In the MEMORAe project the domain is the training itself. Its corresponding ontology has to be linked to application ontologies. Figure 1 shows this integration. The root of the project ontology is memoraObject. First, this concept must be the root of all the concepts belonging to application ontologies. The sub-concept knowledgeBeanObject allows the integration of application ontologies. Their root concept must extend it.

Secondly, the memoraObject concept must also be the root of all the concepts that belongs to the training ontology. Its root is called here trainingOntologyObject. The project defines a special concept called knowledgeBean whose elements are the concepts of application ontologies. They are the notions that learners have to study in the training. This concept extends the specific trainingClass containing all the concepts of the domain ontology.

- memoraObject
  - knowledgeBeanObject
    - Nf01Object
    - B31Object
  - trainingOntologyObject
    - Document
    - Person
    - resourceAcces
    - trainingProperty
    - trainingClass
      - knowledgeBean

*Figure 1.*Integration of ontologies

Elements of the domain ontology

Figure 1 shows the upper elements of the domain ontology. We give in this section more details about it (see Figure 2). Actors of the training program are instances of the concept Person and we consider four categories listed in the figure. A person can also play a role in a relation: author, responsible, or tutor for example. Documents are organized according to their form, more or less structured. We present in Figure 2 the main categories. Each document is associated with a support (ResourceAccess in Figure 2), digital or not. Some elements listed above can be found in the LOM description.

- ResourceAccess
  - Digital
    - Audio
    - Video
    - Text
    - Image
  - Solid
    - Image
    - CD
    - Paper
    - Slide
    - Audiotape
    - Videotape

- Document
  - Picture
    - Graph
    - Diagram
  - Exercise
  - Message
  - Annotation
  - Lecture
  - Index
  - Slide show
  - Book
  - Web page
  - Web site

- Person
  - Administrative
  - Student
  - Technicien
  - Teacher

Figure 2. Elements of domain ontology

TrainingProperty in Figure 1 is the class of relations occurring between concepts. Some are more pedagogical as prerequisite for example. Other are more general as writtenBy that allows to link a document and a person. Some link names are coming from the Dublin Core initiative (http://dublincore.org/documents/dces/) about document indexation. Binary relations have a domain and a range for constraining instances of the relation, but more generally we can include a relation inside a Cartesian product of generic concepts. We write for example writtenBy Ì Document:work ´ Person:author to signify that the relation writtenBy occurs between individual concepts of the concept Document, playing the role of work and individual concepts of the concept Person playing the role of author. We write in the same way: prerequisite Ì knowledgeBean:learnBefore ´ knowledgeBean:learnAfter

When writing application ontology compliant with that domain ontology only few constraints appear:

- The root of the ontology must extend the concept knowledgeBeanObject as nf01Object and b31.1Object in Figure 1.
- Each concept of the application ontology must be an instance of the concept knowledgeBean.
- It is possible to use relations defined in the domain ontology.
- It is possible to create relation between concepts of both ontologies.

Populating the memory

We give an example of annotation to show the way the memory can be populated. An annotation allows to give a suggestion about either one concept or a set of concepts. In the last case, there is no particular relation occurring in the ontology between the concepts that must be annotated. It is not an annotation of each single concept but of the reunion of all. When navigating, it is important and necessary to get the annotation document from any concept that is concerned by this annotation. The domain ontology contains the suggestion_annotation relation defined by: suggestion_annotation Ì Bag:about ´ Annotation:information. Bag is a domain concept that allows to group knowledgeBean elements. Note that we also use this facility for annotating one concept. For example, if we want to give information about the use of the concepts set and complement defined in the statistics ontology, in the population we would have:

a. bag_1, instance of Bag
b. element(Set,bag_1)
c. element(Complement,bag_1)
d. ann_1, instance of Annotation (Annotation is a subclass of Document)
e. suggestion_annotation(ann_1,bag_1)

For indicating the author of the annotation:

f. Abel, instance of Person
g. writtenBy(ann_1,Abel)

A method for building ontologies

The analysis of several research works (Aussenac-Gilles, 2000; Bachimont, 2000; Gomez-Pérez, 1999; Kassel, 2002; Uschold et al., 1996) allows reaching a consensus on ontology building process. It relies on two steps: ontologization and operationalization (see Figure 3).

The ontologization step consists in building a conceptual ontology. Knowledge of a domain is elaborated in two ways:

- Human followed by machine analysis of various kinds of resources such as glossaries, books, courses, other ontologies, texts, etc., revealing terms and semantics structures (Fernandez et al., 1997).
- Expert interviews.

The operationalization step consists in coding the conceptual ontology using an operational knowledge representation language (i.e. equipped with inference mechanisms). This step can lead to loss of information.

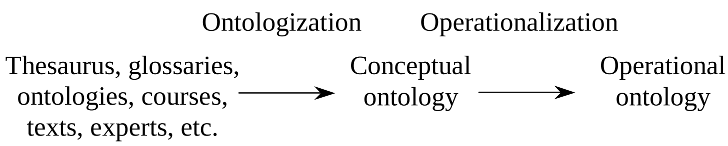

Figure 3. Two main steps in ontology building process

Concepts are often structured using taxonomies. In order to reveal various points of view in taxonomy, the OntoSpec method (Kassel, 2002) introduces the notion of semantic axes (SA). A semantic axe groups the sub-concepts according to their differentia (characteristics which allow to distinguish between sub-concepts). For example, in Figure 4, the set concept is specialized in three axes. The differentia of axe 1 is finite/infinite. In the same way, Guarino and Welty (Guarino, 1992; Guarino & Welty, 2000) propose criteria for properties classification in order to guide construction of taxonomy and to check subsumption links validity.

To build taxonomy of concepts, three approaches can be considered (Fridman & Hafner, 1997):

- Top-Down approach: first top-level ontology concepts are built, and then they are specialized.
- Bottom-Up approach: first low-level ontology concepts are built then they are generalized.
- Middle-out approach: first most important concepts are built, then they are generalized and specialized.

Within the MEMORAe project, we are interested in building a conceptual ontology. For the B31.1 application, we built the conceptual ontology in collaboration with an expert. In order to facilitate the access to the memory resources, we have to represent the notions to acquire according to the different points of view. For these reasons we chose to follow the OntoSpec specification method developed by the LaRIA IC team (http://www.laria.u-picardie.fr/equipe_ingenierie_connaissances.html).

OntoSpec specification method

OntoSpec is a method of semi-informal specification of ontologies (Kassel, 2002). It supposes that a conceptualization is made up of a set of concepts (or conceptual entities) and relations. The concepts in OntoSpec are organized in a taxonomy. Sub-concepts inherit all the properties of their super-concept. The relations make it possible to connect various concepts between them.

A conceptual entity owns a definition and denotes a set of objects having properties. The entity definition structure is based on a classification of these properties. At a first level, the properties are either Essential Properties (EP) or Incidental Properties (IP). The EPs are verified by all the objects denoted by the entity in every situation, or possible world. They are thus really definitional. Conversely, the IPs are satisfied only in a sub-range of situations. At a second level, the properties are classified according to roles they play regarding the conceptual entity. These roles can be abstract, e.g. Necessary Condition (NC), Sufficient Condition (SN), Necessary and Sufficient Condition (NSC). If the entity is defined by NSC, then its definition is complete. It is enough to characterize the entity.

An ontology is a differential set of concepts: the concepts are positioned according to their differences (Bachimont, 2000). In fact, the set of concepts are structured hierarchically and the properties are bound by conceptual properties. The conceptual property that structures a hierarchy of concepts is the subsumption, which binds two concepts: the concept C1 subsumes another concept C2, (respectively the relation R1 subsumes another relation R2, if and only if all instances of C2 are necessarily instance of C1. The sub-concept is more specific than the super-concept and denotes less amount of objects (smaller extension).

Sibling concepts are organized in semantic axes according to their similarities. The set concept is specialized according to three axes: finite/infinite, countable/uncountable, subset/superset (see Figure 4).

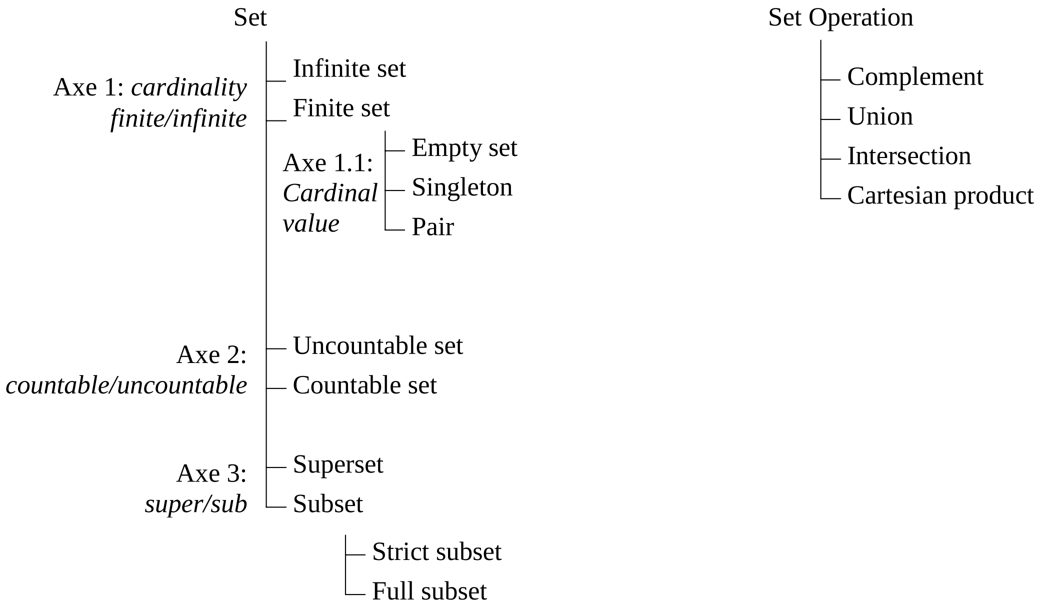

Figure 4. Specializations of the "set" notion

OntoSpec specification method also defines a list of the more specific properties that can be associated to a concept or a relation. This will not be developed here. It is semi-formal because it requires a definition of the conceptual entities (concepts and relations) using a strongly structured language. Figure 5 presents examples of definitions. The labels in square brackets correspond to the distinctions between properties; the underlined texts represent the relations.

Concepts:

- *Finite set*: [EP/NSC] A FINITE SET is a SET which has a cardinal. [EP/NC] Any FINITE SET is COUNTABLE. [PE/NC]. The FINITE SETS are DISTINCT from the INFINITE SETS.
- *Infinite set*: [EP/NSC] An INFINITE SET is a SET which DOES NOT HAVE a CARDINAL. [EP/NC] The INFINITE SETS are DISTINCT from the FINITE SETS.
- *Cardinal*: [PE/NSC] A CARDINAL is a NUMBER which COUNTS THE NUMBER OF ELEMENTS of a SET.

Relations: A CARDINAL counts the number of elements of a UNIT.

- *Has a cardinal* : [EP/NSC] To have a cardinal implies TO BE COUNTABLE. [EP/NC] A CARDINAL counts the number of elements of a SET.

Figure 5. Semi-informal definition of three concepts and of one relation

Application ontologies

We present in this section some excerpts of B31.1 application ontology starting from the definition of two concepts "set" and "operation":
Definition of the conceptual entities associated to the generic concept "set" (see Figure 4):

Concepts:

- SET ; collection of elements [SA]: The concept of SET specializes in FINITE SET and INFINITE SET, according to the relation: HAS A CARDINAL. [SA] The concept of SET specializes in COUNTABLE SET and UNCOUNTABLE SET, according to the relation: COUNTABILITY [SA]. The concept of SET specializes in SUBSET and SUPERSET, according to the relation: PART WHICH THE SET PLAYS COMPARED TO ANOTHER SET.
- Infinite set: [EP/NSC] An INFINITE SET **is a** SET which DOES NOT HAVE a CARDINAL. [EP/NC] The INFINITE SETS are DISTINCT from the FINITE SET.
- Finite set: [EP/NSC] A FINITE SET **is a** SET which **has a cardinal**. [EP/NC] Any FINITE SET is COUNTABLE. [PE/NC] The FINITE SETS are DISTINCT from the INFINITE SETS. [SA] The concept of finite set specializes in PAIR, EMPTY SET and SINGLETON, according to the relation: VALUE OF THE CARDINAL.
- Pair: [EP/NSC] A PAIR **is a** Set SET **has a cardinal** = 2.
- Empty set: [EP/NSC] An EMPTY SET **is a** SET which **has a cardinal** = 0.
- Singleton: [EP/NSC] A SINGLETON is a SET which **has a cardinal** = 1.
- Countable set: [EP/NSC] A COUNTABLE SET **is a** SET which elements can be numbered. [EP/NC] the COUNTABLE SETS are DISTINCT from the UNCOUNTABLE SETS.
- Uncountable set: [EP/NSC] A UNCOUNTABLE SET **is a** SET which cannot number the elements. [EP/NC] the UNCOUNTABLE SETS are DISTINCT from the COUNTABLE SETS.
- Superset: [EP/NSC] A SUPERSET **is a** SET which **contains** all the elements of another SET.
- Subset: [EP/NSC] A SUBSET **is a** SET which has elements **belonging** to ANOTHER UNIT. [SA] The concept of Subset specializes in FULL SUBSET, STRICT SUBSET and COMBINATION, according to the relation: VALUE OF THE CARDINAL.

Relations:

- Has a cardinal: [EP/NSC] TO HAVE A CARDINAL implies to be COUNTABLE. [EP/NC] A CARDINAL counts the number of elements of a SET.
- Contains: [EP/NSC] CONTAINS all the elements of another SET. Implies to be a SUPERSET.

Belonging: [EP/NSC] To have elements BELONGING to another SET. Implies to be a SUBSET.

Definition of the conceptual entities associated to the generic concept "operation" (see Figure 4):

Concepts:

- OPERATION ; **concerns** one or more SETS: [SA] The concept of Operation specializes in COMPLEMENT (NOT), UNION (OR), INTERSECTION (AND) AND CARTESIAN PRODUCT, according to the relation: OPERATION TYPE.
- Complement: [EP/NSC] The COMPLEMENT **is an** OPERATION that **concerns** a SET (A) and a SUBSET (B). The complement of B in A is the set of the elements of A which do not belong to B.
- Union: [EP/NC] The UNION **is an** OPERATION that **concerns** two or several SETS. [EP/NSC] The UNION of two sets A and B is the set of the elements belonging to A or B.
- Intersection: [EP/NC] The INTERSECTION **is an** OPERATION that **concerns** two or several SETS. [EP/NSC] The INTERSECTION of two sets A and B is the set of the elements common to A and B.
- Cartesian product: [EP/NC] The CARTESIAN PRODUCT **is an** OPERATION that **concerns** two SETS A and B. [EP/NSC] the CARTESIAN PRODUCT of A and B is the set of the couples which first element belongs to A and second to B.

Relations:

- Concerns : [EP/NSC] CONCERNS one or more sets. Implies to be an OPERATION.

The following example shows how teaching order information can be expressed:

In order to handle sets, it is necessary to use types of operations, this is specified by the relation "Concerns":
`Concerns`:

- Domain: `complement`.
- Range: `set`.

It is preferable in some situations to use the `Complement` operation to determine the number of combinations of a certain type. For example, if a urn contains 30 red balls and 20 white balls, to solve the question: "how much manners are there to choose five balls with at least one white ball?", it is better to solve first the question: how much manners are there to choose five balls without white ball. It was also possible to use the `"union"` operation, but with the `Complement` operation, the solution of the problem is easier to find.

With this intention, it is necessary to relate these two concepts `(Set and Complement)` although this relation neither appears in the formal definition of "`complement`" nor in the one of "`set`". For this purpose, we group these two concepts and link an annotation to the group. The annotation specifies the reason why the group is made. The definition of group is in the domain ontology. It is called "`Bag`" and can relate two or more concepts. The link called "`suggestion_annotation`" is defined in the application ontology:

- suggestion_annotation $\subset$ Bag:about $\times$ Annotation:information

Implementation

We have implemented a prototype that allows the management of a learning organizational memory. This prototype has several functionalities related to edition, administration, search and consultation aspects. It uses the Topic Maps formalism to represent information. This formalism is based on three main elements Topic, Association and Occurrence. Since 2001 it has an XML implementation, XTM (TopicMaps.org, 2001). Figure 6 shows how an annotation can be associated to a bag through a suggestion_annotation link, using this formalism and gives an illustration of section *Populating the memory*, line e. "bag_1" and "ann_1" are respectively instances of "Bag" and "Annotation".

```
<association id= "A-N001" >
    <instanceOf>
           <topicRef xlink:href="#suggestion_annotation" />
    </instanceOf>
    <membre>
           <roleSpec><topicRef xlink:href="#about"/></roleSpec>
           <topicRef xlink:href="#bag_1"/>
    </membre>
    <membre>
           <roleSpec><topicRef xlink:href="#information"/></roleSpec>
           <topicRef xlink:href="#ann_1"/>
    </membre>
</association>
```

Figure 6. Association of an annotation to a suggestion link

Figure 7 shows how to create a link to a resource using the element Occurrence.

```
<topic id="ann_1">
  <occurrence>
    <instanceOf>
      <topicRef xlink:href="#web-page" />
    </instanceOf>
    <resourceRef xlink:href="http://………/statistics/annot1.html"/>
  </occurrence>
</topic>
```

Figure 7. Association of a resource to a topic with an occurrence link

Of course users do not have to know the TM formalism, they access to the memory through an interface. Figure 8 shows a snapshot of the navigation interface. There are two ways to begin to consult the pedagogical content of a course memory. The user can select either one of the available entry points in the left frame, or one of the course notions presented in the right frame. This latter frame initially shows the first specialization level of the application (B31.1 in the example) ontology concepts.

Entry points are chosen by the head of the course. They depend on the learning strategy he wants to enhance. They allow to directly access to a part of the memory. When a user selects an entry point, the associated part of the memory appears in the middle frame. It is in fact a guided navigation through the memory (entry points selected in their presentation order). The user is however free to navigate through the memory by using the left frame if he prefers

In case of a free navigation, information is always presented in the same order in the right frame:

- Path used to reach the selected notion
- Brief text definition of the notion
- Related notions (using the first ontology level)
- Related resources

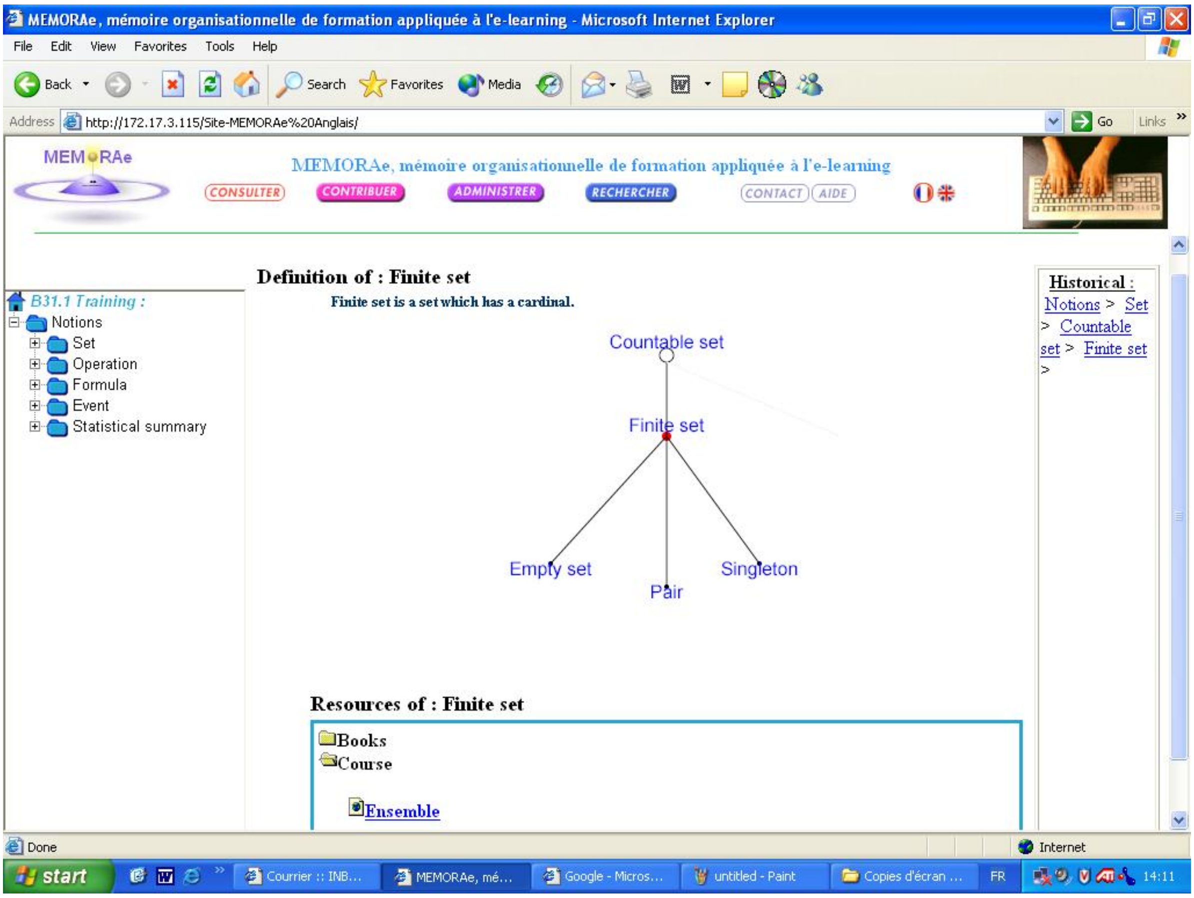

Figure 8. Snapshot of the prototype interface

To access to a resource, user has to select one of its index. Then, he has to click on the term representing the resource in the list of resources associated to this index in order to open a new window containing a description of the selected resource (case of a paper resource) or the resource itself (case of a digital resource).

Related work

Unlike a learning organizational memory proposed in our approach, a Learning Content Management System (LCMS) is an environment where developers can create, store, reuse, manage and deliver learning content from a central object repository, usually a database. LCMS generally work with content that is based on a learning object model (Hall 2001). These systems usually have good search capabilities, allowing developers to find quickly the text or media needed to build training content. They often strive to achieve a separation of content, which is often tagged in XML, from presentation.

From the same author, Learning Objects (LO), also called Reusable Learning Objects, are rather a philosophy for how content can be created and deployed. Learning Objects refer to self-contained chunks of training content that can be assembled with other Learning Objects to create courses and curricula, much the same way a child's Lego blocks are assembled to create all types of structures.

Learning Objects are designed to be used in multiple training contexts, aim at increasing the flexibility of training, and make course updating much easier to manage. When a learning object is updated, the change appears in any course using that learning object.

Within the MEMORAe project, we do not create resources. We choose a set of existing resources with their original format and goal. We index these resources by the means of ontologies (domain and application). These resources are not modified but can be annotated according to the choice of the memory manager. They are retained in their whole, interesting parts can only be highlighted. Authors are free to create resources in their own way. An application ontology has to be built for each course.

Conclusion

In this paper we addressed the problems related to pedagogical resources management for e-learning. To organize the resources in a learning organizational memory, we rely on ontologies. We consider two kinds of ontologies: the first one is generic and concerns the domain of training. The second one is related to the application domain, it is specific to a particular training program. We described our approach for building these ontologies and illustrated it with some examples of the learning memory we designed for two courses of our universities.

This research work is thus situated at the crossroad of three domains: knowledge engineering, pedagogical design and semantic web. The determination of knowledge grains and links between them relates to pedagogical design. The choices of organization, the management of resources in an ontology-based learning organizational memory concerns knowledge engineering. Finally, the choice of the ISO Topic Maps (Park, 2002) standard for representing the memory and allowing its consultation is connected with the semantic web domain.

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Moreale, E., & Vargas-Vera, M. (2004). Semantic Services in e-Learning: an Argumentation Case Study. *Educational Technology & Society*, 7 (4), 112-128.

Semantic Services in e-Learning: an Argumentation Case Study

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Abstract

This paper outlines an e-Learning services architecture offering semantic-based services to students and tutors, in particular ways to browse and obtain information through web services. Services could include registration, authentication, tutoring systems, smart question answering for students' queries, automated marking systems and a student essay service. These services – which might be added incrementally to the portal – could be integrated with various ontologies such as ontologies of educational organisations, students and courses.

In this paper, we describe a few scenarios in the e-learning domain and illustrate the role of a few services. We also describe in some detail a service doing semantic annotation of argumentation in student essays for allowing visualization of argumentation and providing useful feedback to students.

Keywords

Semantic Services for e-Learning, Services Composition, Semantic Web, Argumentation in Student Essays

Introduction

The current Web was designed primarily for human interpretation and use (McIlraith *et al*., 2001). Originally a repository for text and images, the Web has been turning into a provider of services. These include information-booking). These are currently built through hand-coded information extraction code locating and extracting relevant information from HTML pages written for humans. However, this approach is error-prone and will fail every time the presentation layout is changed. A better approach would be to provide machine-readable content that can be used by agents/programs to perform intelligent activities.

The aim of the semantic web is exactly to provide this extra layer, to add structure or meaning to what is on the Web thus allowing intelligent navigation, personalization, querying and retrieval. This structuring could be performed by annotating documents in the web with semantics that can be later used by computers/agents to reason and perform sophisticated tasks for users. Therefore, in order to achieve the goals of the semantic web, computers must have access to structured collections of information and a set of inference rules that can be used to perform automated reasoning (Berners-Lee et al., 2001; Hendler et al., 2002). An important pre-condition for realizing the goal of the semantic web is therefore the ability to annotate web resources with semantic information. To carry out this task, users need appropriate *knowledge representation languages*, *ontologies*, and *support tools*. Knowledge representation languages provide the semantic interlingua for expressing knowledge precisely. The Semantic Web "layer cake" (Berners-Lee 2001, Hendler 2001) shows the proposed layers of the Semantic Web with higher-level languages using the syntax and semantics of lower levels: e.g. RDF builds on top of XML and Ontologies on top of RDF (Figure 1). We will focus on ontologies, as they serve as core structure for semantic portals (Studer et al., 2002). We describe semantic portals in the section titled "Demystifying Semantic Portals".

Our test bed is academic life of an institution, seen through the student semantic portal. Differently from traditional portals, such as 'Amazon' or 'Yahoo', in our student semantic portal inference processes are performed in order to provide intelligent services.

Our work has so far concentrated on two components of the portal: the student essay system (Moreale and Vargas-Vera, 2004; Moreale and Vargas-Vera, 2003) and a question-answering component called AQUA (Vargas-Vera et al., 2004; Vargas-Vera et al., 2003). AQUA searches for answers in different resources such as ontologies and documents on the web. We envisage the use of these components as part of a student semantic portal, seen as a door to obtain knowledge.

The main idea behind the student essay component consists in extracting arguments from a particular type of document: essays written by students. Extraction of arguments from documents is an interesting research problem in natural language research and has many potential applications, ranging from text classification and document summarization to the semantic web. For instance, document summarization could improve the performance of search engines dramatically: by allowing searching the summary of a document (rather than its full text), it would focus on relevant documents and skip the irrelevant information currently obtained by keyword-based search engines.

Research into identification of arguments in research papers has relied on a conceptualization of academic paper structure: a paper is typically seen as containing an introduction, results and other interesting sections (e.g. paper contributions, usually identified through some heuristics). However, a student essay presents a somewhat different challenge: while containing background and approach comparisons, they do not usually contain original contributions to knowledge. More importantly, their structure is less predictable than that of academic papers and cannot therefore be totally relied upon in devising a strategy for argument extraction.

In this paper, we present the proposal for a student semantic portal with several services, including a student essay service providing annotation of student essays using an argumentation categorization devised specifically for student essays. We claim that a visualisation of the arguments presented in student essays could benefit both tutors and students. On the one hand, it would enable time-constrained tutors to easily locate the most "interesting" (argumentation-rich) parts of student essays, allowing them to determine if the essay covers the required "points" and probably spot correlations between highlighted parts. On the other hand, such a visualisation could help students "see" if their essay contains enough of the expected type of argumentation.

The main contributions of this paper are as follows: a proposal for a student semantic portal, the outline of a few e-learning scenarios, a categorization schema for student essays used by the student essay service, one of the components of our portal, which is described as a case study.

The paper is organised as follows: we first introduce semantic portals and possible roles of the semantic web in e-learning; we then describe our proposed architecture for e-learning services (annotations, ontologies and services) including an e-learning scenario. We discuss a case study covering an essay annotation service after discussing the research background on argumentation schemas in papers and argument modelling. The section entitled "Proposed Solution" describes our proposed annotation schema, illustrating how the service may be used in an e-learning scenario. Finally, the paper presents our conclusion.

Demystifying Semantic Portals

The multiplication of web sites led to the need for web portals, sites providing access to collections of interesting URLs and "dumb" (i.e. keyword-based) search for information. Similarly, a semantic portal can be seen as an entry point to knowledge resources that may be distributed across several locations. However, differently from "dumb" web portals, semantic portals are "smarter" and carry out intelligent reasoning behind the scenes. They should offer semantic services including semantics-based browsing, semantic search and smart question answering. *Semantic browsing* locates metadata and assembles point-and-click interfaces from a combination of relevant information (Quan and Karger, 2004): it should be allow easy navigation through resources, since users with any level of computing knowledge may use it. *Semantic search* enhances current search engines with semantics: it goes beyond superficial keyword matching by adding semantic information, thus allowing easy removal of non-relevant information from the result set. *Smart question answering* is the technique of providing precise answers to a specific question. For instance, given a question such as "Which country had the highest inflation rate in 2002?", the system would directly reply to the question with the name of the country, as opposed to the approach of current search engines (such as Google) which might present users with web pages from the Financial Times. All these services would be built on top of functionality such as machine access to semantic information and semantic ranking (Stojanovic et al., 2001). *Semantic ranking* may be useful in those cases when too many results are returned: it allows alleviating information overload by ordering the results using different criteria. An example is ranking by popularity news stories in an electronic newsletter (http://kmi.open.ac.uk/news/planetarchive.html).

We envision a scenario where educational services can be mediated on student behalf. The user/student will confirm that suggestions are acceptable. The advantage of having a semantic portal is that students need not look for courses distributed across many locations (unlike current solutions). Moreover, semantic services perform inferences in the background (taking into account student preferences) as opposed to having users manually searching the traditional way.

From a pedagogical perspective, semantic portals are an “enabling technology” allowing students to determine the learning agenda and be in control of their own learning. In particular, they allow students to perform semantic querying for learning materials (linked to shared ontologies) and construct their own courses, based on their own preferences, needs and prior knowledge. By allowing direct access to knowledge in whatever sequence students require them, *just-in-time learning* (Stojanovich, 2001b) occurs. At the other end of the spectrum, tutors are freed from the (now student-run) task of organising the delivery of learning materials but must produce materials that stand on their own. This includes properly describing content and contexts in which each learning material can be successfully deployed. One possibility is metadata, i.e. tags about data that allow describing, indexing and searching for data.

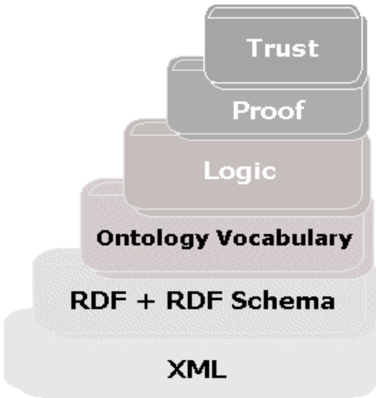

Figure 1. Semantic Web Layers

XML (http://www.w3.org/XML/) allows users to add arbitrary structure to their document by creating tags to annotate a web page or text section. Although the meaning of XML tags is intuitively clear, tag names by themselves do not provide semantics (Stojanovich *et al.*, 2001b). XML (DTDs and XML-Schema, www.w3.org/XML/Schema) is not appropriate for propagating semantics through the semantic web, but is used as a “transport mechanism”. RDF (Resource Description Framework) (Hayes, 2002; Lassila and Swick, 1999) and RDFS (Brickley and Guha, 2000) provide a basic framework for expressing metadata on the web, while current developments in web-based knowledge representation, such as DAML+OIL (http://www.daml.org/2001/03/reference.html) and OWL (http://www.w3.org), build on RDF to provide more sophisticated knowledge representation support.

Relation between e-Learning and the Semantic Web

E-learning is an area which can benefit from Semantic Web technologies. Current approaches to e-Learning implement the teacher-student model: students are presented with material (in a limited personalized way) and then tested to assess their learning. However, e-learning frameworks should take advantages of semantic services, interoperability, ontologies and semantic annotation. The semantic web could offer more flexibility in e-learning systems through use of new emergent semantic web technologies such as collaborative/discussion and annotations tools.

Annotation

Annotation is the activity of annotating text documents written in plain ASCII or HTML with a set of tags that are the names of slots of the selected class in an ontology. In particular, in an e-learning context, the ontology could include a class called Course with slots entitled “name” (indicating the name of the course), “has-level” (year/difficulty of the course), “has-provider” (educational establishment offering the course) and “objectives” (indicating learning outcomes). Then documents can be annotated using any of these slots.

There are initiatives to standardize annotations using a common language. One of the major problems of this approach is "who is going to do the annotations?" Not many people are willing to annotate resources unless they can see an immediate gain in doing it. Therefore, alternative approaches should be considered, including (semi-) automated systems. This approach was taken in the student essay annotation system described later.

Annotation tools for producing semantic markup include Annotea (Kahan *et al*., 2001); SHOE Knowledge Annotator (Heflin and Hendler, 2001); the COHSE Mozilla Annotator (Bechhofer and Goble, 2001); AeroDAML (Kogut and Holmes, 2001); Melita (Ciravegna *et al*., 2002) and, OntoMat-Annotizer (Handschuh *et al*., 2001).

- Annotea provides RDF-based markup but does not support information extraction nor is it linked to an ontology server. It does, however, have an annotation server, which makes annotations publicly available.
- SHOE Knowledge Annotator allows users to mark up pages in SHOE guided by ontologies available locally or via a URL. SHOE-aware tools such as SHOE Search can query these marked up pages.
- The COHSE Mozilla Annotator uses an ontology server to mark up pages in DAML. The results can be saved as RDF.
- AeroDAML is available as a web page. The user simply enters a URL and the system automatically returns DAML annotations on another web page using a predefined ontology based on WordNet.
- Melita, like MnM, provides information extraction-based semantic annotation. Work on Melita has focused on Human-Computer Interaction issues such as limiting intrusivity of the information extraction system and maximizing proactivity and timeliness in suggestions. Melita does not provide sophisticated access to the ontology, unlike MnM. In this sense Melita explored issues complementary to those explored in developing MnM and the two approaches could be integrated.
- OntoMat, which uses the CREAM annotation framework, is closest to MnM in both spirit and functionality. Both allow browsing of predefined ontologies as a means of annotating the web pages displayed using their HTML browsers. Both can save annotations in the document or as a knowledge base. While MnM already provides automated extraction, this is currently only planned for Ontomat.
- MnM (Vargas-Vera *et al*., 2002) is an annotation tool, which provides both automated and semi-automated support for marking up web pages with semantic contents. MnM integrates a web browser with an ontology editor and provides open APIs to link up to ontology servers and for integrating information extraction tools. It is an early example of the next generation of ontology editors: web-based, oriented to semantic markup and providing mechanisms for large-scale automatic markup of web pages.

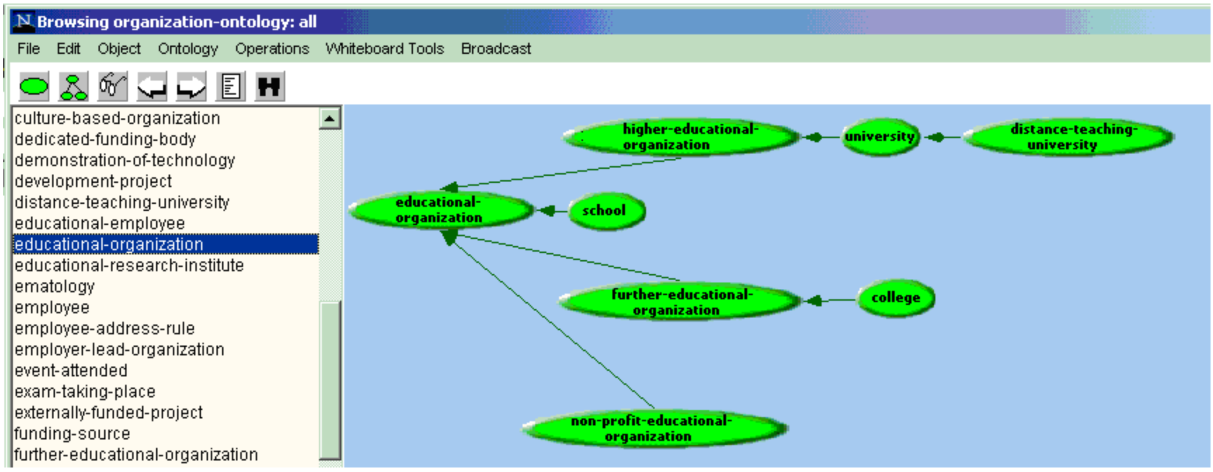

Figure 2. e-learning Ontology : Educational-Organization

Ontologies

Ontologies are explicit formal specifications of the terms in the domain and the relations among them (Gruber, 1993): they provide the mechanism to support interoperability at a conceptual level. In a nutshell, the idea of interoperating agents able to exchange information and carrying out complex problem solving on the web is based on the assumption that they will share common, explicitly-defined, generic conceptualizations. These are typically models of a particular area, such as product catalogues or taxonomies of medical conditions. However, ontologies can also be used to support the specification of reasoning services (McIlraith et al., 2001; Motta, 1999; Fensel and Motta, 2001), thus allowing not only 'static' interoperability through shared domain conceptualizations, but also 'dynamic' interoperability through the explicit publication of competence specifications, which can be reasoned about to determine whether a particular semantic web service is appropriate for a particular task.

Ontologies can be used in e-learning as a formal means to describe the organization of universities and courses and to define services. An e-learning ontology should include descriptions of educational organizations (course providers), courses and people involved in the teaching and learning process. Some suggestions are outlined below using snapshots created using WebOnto (Domingue, 1998).

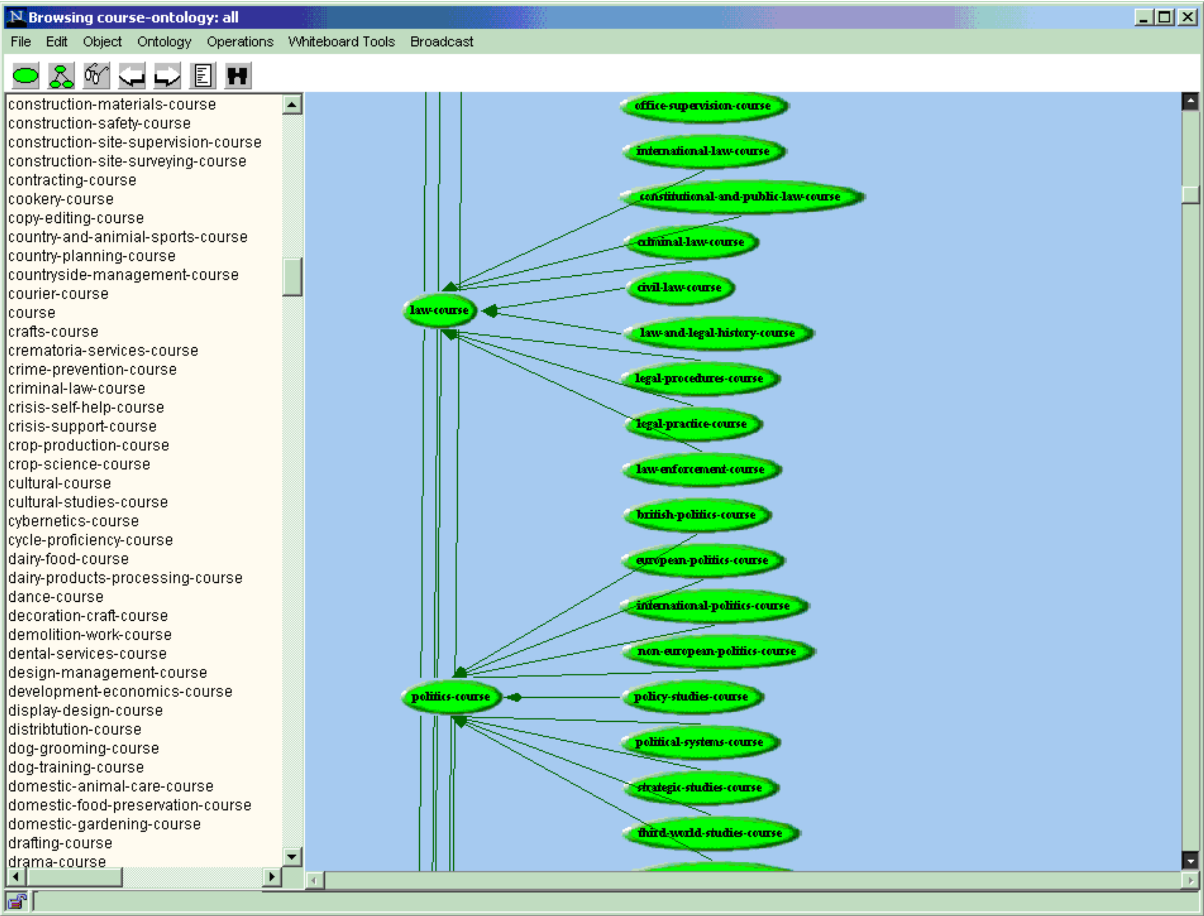

Figure 3. e-learning Ontology: Courses

Scenario

Let us consider Maria's scenario. Maria wants to enroll in an English course in a University in Britain in summer 2004. A smart search service could analyze Maria's current location, locate English courses run by British Universities and book a ticket for Maria to reach her destination from start location. This is a simple scenario, which the broker can split into several simple semantic services such as enroll-in-a-course, payment, accommodation, arrange-transport and so on. A formal specification for Maria's request is shown below. It is written in First Order Logic using Prolog notation (Clocksin & Mellish, 1981).

```
request  :-      enroll( maria, english_course) &
                 location( english_course, britain) &
                 time( english_course, summer_2004)
```

By using the Educational-Organization ontology, we could reformulate the request as follows:

```
request  :-      enroll( maria, english_course) &
                 is-a( educational_organisation, university)
                 location( english_course, britain) &
                 time( english_course, summer_2004)
```

The user in natural language could submit this request. A natural language parser that would map it into first order logic predicates could then process it. Then the request needs to be reformulated and expressed in terms of entities and relations in the subscribed ontology. This is achieved by using similarity algorithms to perform the mapping. If the similarity algorithm does not succeed in this mapping, then the user would have the possibility of entering data using templates instantiated with values (services) specified in the ontology.

The broker splits the goal into sub-goals and requests a set of semantic services which should take Maria's constraints into consideration before taking decisions on her behalf.

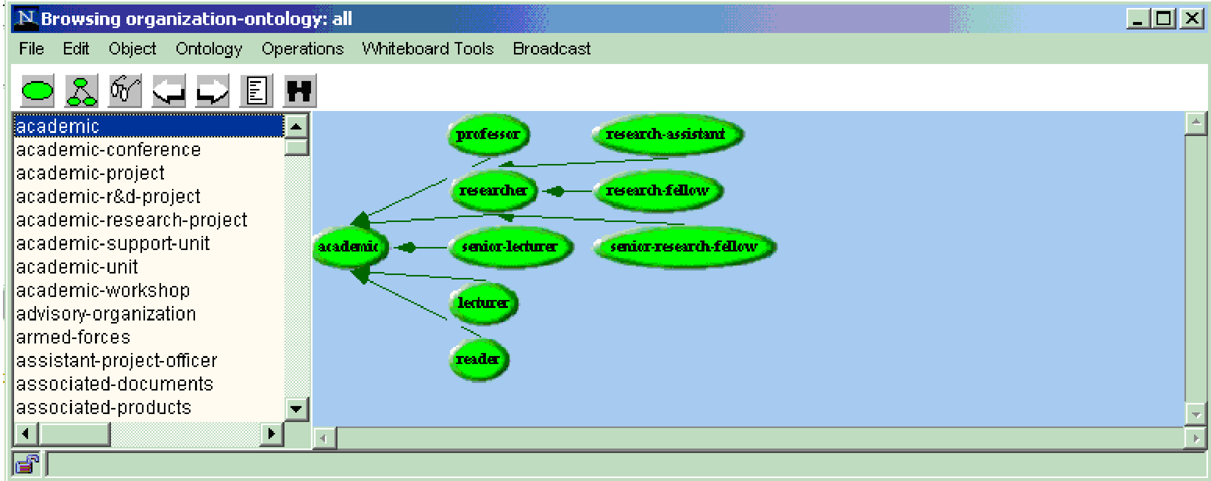

Figure 4. e-learning Ontology: Academic

Services

Services can be seen as functions in Functional Programming Languages. Complex services can be obtained by combining simple services. In the simplest case, composition can be reduced to compose functions like in Mathematics. If we take this perspective, then a semantic service is a function with Parameters, Preconditions & Effects, Input and Output. Then the composition can be defined formally as follows:

$$F1 \circ F2 \circ \ldots \circ Fn\ (X) = (F1(F2(F3 \ldots (Fn(X)) \ldots))$$

However, the combination of services can be more complex. Semantic services can be described as Logic statements. Then the composition problem can be seen as merging logic statements with constraints. Work reported in (Vargas-Vera 1994; Vargas-Vera 1995) describes an automatic system which combines logic programs using program histories. This approach could be adapted to the composition problem since each service can be seen as a logic program and we also have histories for each service describing its functionality and restrictions imposed by the service creator. Further research needs to be carried out in this direction.

Another, equally important challenge, which needs to be addressed in the web services arena is that, when services are subscribed to different ontologies, then our framework has to deal with ontology mapping between ontologies. There are several approaches to ontology mapping such as the one taken in the GLUE system (Doan et al., 2002); Noy et al. also developed a tool for ontology alignment (Noy et al. 2000).

Architecture of the Student Semantic Portal

This section describes our proposed architecture for a student semantic portal. Architecturally, a semantic portal consists of a user who has access to services, repositories and databases through an interface. Figure 5 gives an overview of the overall architecture in the e-learning scenario and specifies details of services in the e-learning domain.

In this architecture, the first step would be registering each service with a registry (not shown), so that services can then be invoked through the service broker. The broker is a central component in this distributed architecture: it allows communication between service providers and requesters. In particular, it attempts to match a request for a service to the closest service that can provide that functionality. Services interact with resources and, in particular, subscribe to relevant ontologies. Other resources include databases and documents published on the Internet.

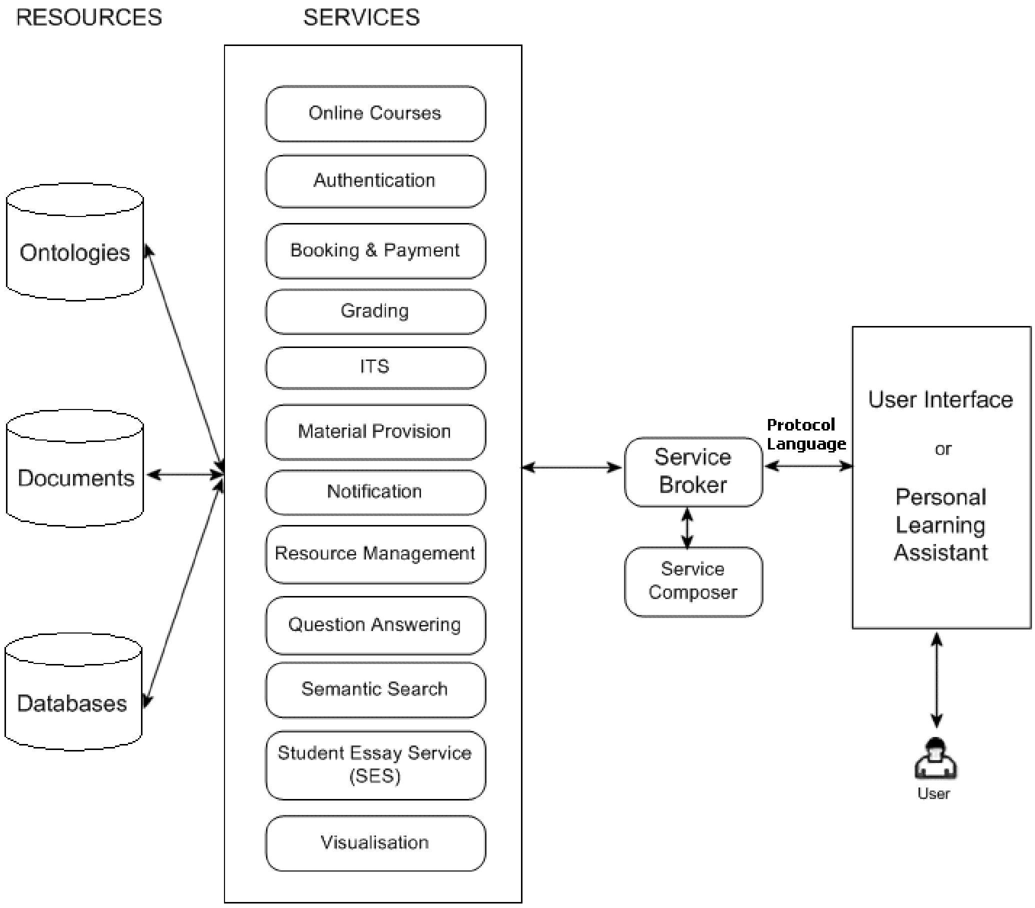

Figure 5. Proposed Architecture for e-Learning Services

An e-learning portal might include services such as smart question answering, exam marking, intelligent tutoring systems, online courses and a service to help students improve their essays. Of these services, we have so far deal with the implementation of a question-answering service (AQUA) and a student essay service (SES). AQUA is described in detail elsewhere and we refer the reader to these papers (Vargas-Vera et al., 2004; Vargas-Vera et al., 2003) for a more thorough description.

This paper will deal with SES, a service that annotates argumentation in student essays to help students write better essays that answer the essay question.

Scenario

To illustrate the architecture, we will now go through an e-learning scenario. A student first searches for an online course (optionally specifying any constraints): the broker handles the request and returns a set of choices satisfying the query. If no course is found, the user can register with a notification service. Otherwise, the user may find a suitable course among the offerings and then makes a final decision about registering for the course.
Processing the registration can be seen as a complex service involving registering with the system (resource management), creating a confirmation notification, creating a student account (authentication/authorization), providing learning materials (provide materials) and processing payment (booking & payment) if applicable. Once all this is in place, the student can start the course. As part of the course, a student will be logging on and checking her learning agenda (e.g. next assignment due). This request is answered by combining several sources of information, such as course schedule, current date and student progress to date (e.g. completed units). Let us imagine that the student needs to submit an essay on topic X. The student will be able to submit the essay for annotation of argumentation in it. The broker will redirect this query to the Student Essay Service (SES) which,

in turn, will make use of argumentation ontologies and tutor-specified settings. If a visualisation of the argumentation was also requested, the SES will forward this request to the visualisation service via the broker. This visualisation service would simply return a visualisation, given a dataset, similarly to the chart option in Microsoft Excel. This concludes our e-learning scenario, which exemplified the use of several services. More details of SES, question types and annotation schemas follow in the next few sections.

Case Study

To illustrate the rationale behind SES, we first need to introduce the concept of argumentation.

Argument Modelling Background

Argumentation research spans from argumentation found in research papers to knowledge representation tools supporting the construction of rhetorical arguments.

An important strand of research has focused on paper structure, producing metadiscourse taxonomies applicable to research papers. In his CARS model (Table 1), Swales (Swales, 1990) synthesized his findings that papers present three moves: authors first establish a territory, then a niche and finally they occupy this niche. Although his analysis focused on the introductory part of an academic paper, his model has nevertheless been influential.

Table 1. Swales's CARS model

<table>
<tr><td colspan="3">Move 1: Establishing a Territory</td></tr>
<tr><td>Step 1</td><td>Claiming Centrality</td><td>Recently, there has been wide interest in…</td></tr>
<tr><td>Step 2</td><td>Making Topic Generalizations</td><td>A standard procedure for assessing has been…</td></tr>
<tr><td>Step 3</td><td>Reviewing Items of Previous Research</td><td>Verbs like show, demonstrate, establish</td></tr>
<tr><td colspan="3">Move 2: Establishing a Niche</td></tr>
<tr><td>Step 1a</td><td>Counter-claiming</td><td rowspan="4">Negative or quasi negative quantifiers (no, little); Lexical negation (verbs like fail or lack, adjectives like misleading); negation in the verb phrase, questions, expressed needs/desires/interests (The differences need to be analysed), logical conclusions, contrastive comments and problem-raising</td></tr>
<tr><td>Step 1b</td><td>Indicating a gap</td></tr>
<tr><td>Step 1c</td><td>Question-raising</td></tr>
<tr><td>Step 1d</td><td>Continuing a tradition</td></tr>
<tr><td colspan="3">Move 3: Occupying a Niche</td></tr>
<tr><td>Step 1a</td><td>Outlining purposes</td><td rowspan="2">This, the present, we, reported, here, now, I, herein</td></tr>
<tr><td>Step 1b</td><td>Announcing present research</td></tr>
<tr><td>Step 1c</td><td>Announcing principal findings</td><td>The purpose of this investigation is to …</td></tr>
<tr><td>Step 1d</td><td>Indicating RA structure</td><td>The paper is structured as follows…</td></tr>
</table>

Others (Teufel et al., 1999) extend Swales's CARS model by adding new moves to cover a whole paper. Their annotation schema aims to mark the main element in a research paper: its purpose in relation to past literature. They classify sentences into background, other, own, aim, textual, contrast and basic categories.

Table 2. Teufel's Annotation Schema (modified)

BACKGROUND	Statements describing some (generally-accepted) background knowledge
OTHER	Sentences presenting ideas attributed to some other specific piece of research outside the given paper
OWN	Statements presenting the author's own new contributions;
AIM	Sentences describing the main research goal of the paper;
TEXTUAL	Statements about the textual section structure of the paper;
CONTRAST	Sentences contrasting own work to other work;
BASIS	Statements to the effect that current work is based on some other work or uses some other work as its starting point;

The authors claim that this methodology could be used in automatic text summarization, as this requires finding important sentences in a source text by determining their more likely argument role. However, theirs is not an implemented system. Experiments in manual annotation showed that the schema can be successfully applied by human annotators.

Hyland (Hyland, 1998) describes a metadiscourse schema that distinguishes between textual and interpersonal types in academic texts (Table 3). Textual metadiscourse refers to devices allowing the recovery of the writer's intention by explicitly establishing preferred interpretations; they also help form a convincing and coherent text by relating individual propositions to each other and to other texts. Interpersonal metadiscourse expresses a writer's persona by alerting readers to the author's perspective towards the information and the readers themselves.

Table 3. Hyland's Taxonomy: Functions of Metadiscourse in Academic Texts

Category	Function	Examples
Textual Metadiscourse		
Logical connectives	express semantic relation between main clauses	In addition, but, therefore, thus, and
Frame markers	explicitly refer to discourse acts/text stages	Finally, to repeat, our aim here, we try
Endophoric markers	refer to information in other parts of the text	Noted above, Fig 1, table 2, below
Evidentials	refer to source of information from other texts	According to X, (Y 1990), Z states
Code glosses	help reader grasp meaning of ideational material	Namely, e.g., in other words, such as
Interpersonal Metadiscourse		
Hedges	Withhold writer's full commitment to statements	Might, perhaps, it is possible, about
Emphatics	Emphasize force of writer's certainty in message	In fact, definitely, it is clear, obvious
Attitude markers	Express writer's attitude to prepositional content	Surprisingly, I agree, X claims
Relational markers	Explicitly refer to/build relationship with reader	Frankly, note that, you can see
Person markers	Explicitly reference to author(s)	I, we, my, mine, our

Other research has focused on supporting construction of rhetorical arguments and tools for "making thinking visible" or helps with essay writing (Sharples and O'Malley, 1988). Both Belvedere (Suthers et al., 1995) and SenseMaker (Bell, 1996) are about the development of scientific argumentation skills in unpracticed beginners and focus on rhetorical relations between propositions (evidence, claims and explanations). Their approach would not be suitable in our case, since our annotation schema aims to model generic (not only scientific) argumentation.

Table 4. Rhetorical Relations in ScholOnto's ClaiMaker Tool

Link Type	Link
General Various useful links	Is about, uses, applies, is enabled by, improves on, impairs, other link
Problem-related Links to connect to concepts that are research problems	Addresses Solves
Supports / Challenges Links to use for connecting evidence and arguments to concepts that are hypotheses or positions taken by the author	Proves, refutes, is evidence for, is evidence against, aggress with, disagrees with, is consistent with, is inconsistent with
Similarity Links to tie together similar concepts, or concepts to be specified as different	Is identical to, is similar to, is analogous to, shares issues with, is different to, is the opposite of, has nothing to do with, is not analogous to
Causal Links to tie up causes and effects, or indicate that certain conditions have been eliminated as possible causes	Predicts, envisages, causes, is capable of causing, is prerequisite for, is unlikely to affect, prevents

Finally, ScholOnto is a project aiming to model arguments in academic papers and devise an ontology for scholarly discourse (Buckingham Shum et al., 2002). They classify claims as general, problem-related, taxonomic, similarity or causal.

They view academic research papers as a set of inter-linked parts and their approach is to manually link statements in one paper with statements in others, leading to a network of cross-referring claims being constructed. However, our motivation is different, because we are dealing with student essays, from which we want to extract arguments in an automated way. Although automated extraction of arguments is difficult, we believe that a shallow analysis of the text can still give us clues about arguments in student essays.

Our argumentation categories are: definition, reporting, positioning, strategy, problem, link, content/expected, connectors and general.

Compared to Teufel's annotation scheme, our schema lacks an AIM category, as student essays implicitly aim to answer the essay question. Similarly, Teufel's distinction between OTHER and OWN (troublesome for human annotators) is irrelevant in our domain. Conversely, the content/expected category is student essay-specific: it includes cue phrases identifying content expected to be found in the essay. Yet, overall, there are remarkable similarities across these taxonomies (Moreale and Vargas-Vera, 2003, Table 6).

Table 5. Our Taxonomy for Argumentation in Student Essays

Category	**Description**	**Cue phrases (examples)**
DEFINITION	Items relating to the definition of a term. Often towards the beginning. IS_ABOUT, COMPARISONS	is about, concerns, refers to, definition; is the same; is similar /analogous to;
REPORTING	Sentences describing other research in neutral way	"X discusses", "Y suggests", "Z warns"
POSITIONING	Sentences critiquing other research VIEWPOINTS	"I accept", "I am unhappy with", "personally";
STRATEGY	Explicit statements about the method or the textual section structure of the essay	"I will attempt to", "in section 2"
PROBLEM	Sentences indicating a gap or inconsistency, question-raising, counter-claiming	"There are difficulties", "is problematic", "impossible task", "limitations"
LINK	Statements indicating how categories of concepts relate to others TAXONOMIC, EVIDENCE, CAUSAL	"subclass of", "example of", "would seem to confirm", "has caused"
CONTENT/ EXPECTED	Any concept that the tutor expects students to mention in their essay. Tutor-editable	Essay-dependent
CONNECTORS	Links between propositions may serve different purposes (topic introduction, support, inference, additive, parallel, summative, contrast, reformulation)	"With regard to", "As to", "Therefore", "In fact", "In addition", "Overall", "However", "In short"
GENERAL	Generic association links	"is related to"

A last strand of research involves Rhetorical Structure Theory (RST). RST (originally developed at the Information Sciences Institute, USC) is designed to enable the analysis of text: it focuses on specifying the evident role of every part of text (Mann, 1988). RST has been applied to enhancing e-rater with discourse-marking capabilities (Burstein *et al.*, 1998). While this is a generic (not a student essay or academic-specific) categorisation, it has its rightful place here.

Proposed Solution

After examining the appropriateness of various Natural Language Processing (NLP) techniques (Moreale and Vargas-Vera 2003), we concluded that the best solution for our purposes would be finding claims in student essays by using an approach that combines cue phrases with a set of patterns. We started off by defining gazetteers of cue phases and patterns written as regular expressions. The set of patterns were organised based on our categories (Table 5).

The proposed architecture of SES comprises: segmentation, categorization and annotation modules.

- The segmentation module obtains segments of student essays by using a library of cue phrases and patterns.
- The categorization component classifies the segments as one of our categories.
- The annotation module annotates relevant phrases as belonging to one of our defined categories. These annotations are saved as semantic tags. Future implementation of the system could use machine learning for learning cue phrases.

Table 6. Our Essay Metadiscourse Taxonomy and Other Categorisations

Category Name	**Relationship to Other Categorizations**	
DEFINITION	ClaiMaker: is about	
COMPARISON	Teufel's CONTRAST	
REPORTING	Swales: Move 1, Step 3; Teufel: OTHER; Hyland: EVIDENTIALS	
POSITIONING	Swales: Move 2 (Establishing a Niche); Teufel's CONTRAST; Hyland: Emphatics, Attitude markers, Person markers	Hyland: Interpersonal Metadiscourse
VIEWPOINT	Hyland: Hedges	
STRATEGY	Swales: Purpose: M3, S1a; Structure:M3, S1d Teufel: TEXTUAL; Hyland: Endophoric markers	
PROBLEM	Swales: Move 2 (Establishing a Niche)	
TAXONOMIES	ClaiMaker: Taxonomic	
EXPECTED/CONTENT		
CONNECTORS	Hyland: Logical Connectives, Frame Makers, Code glosses	Hyland: most of Textual Metadiscourse
GENERAL	ClaiMaker: General link type (except is about)	

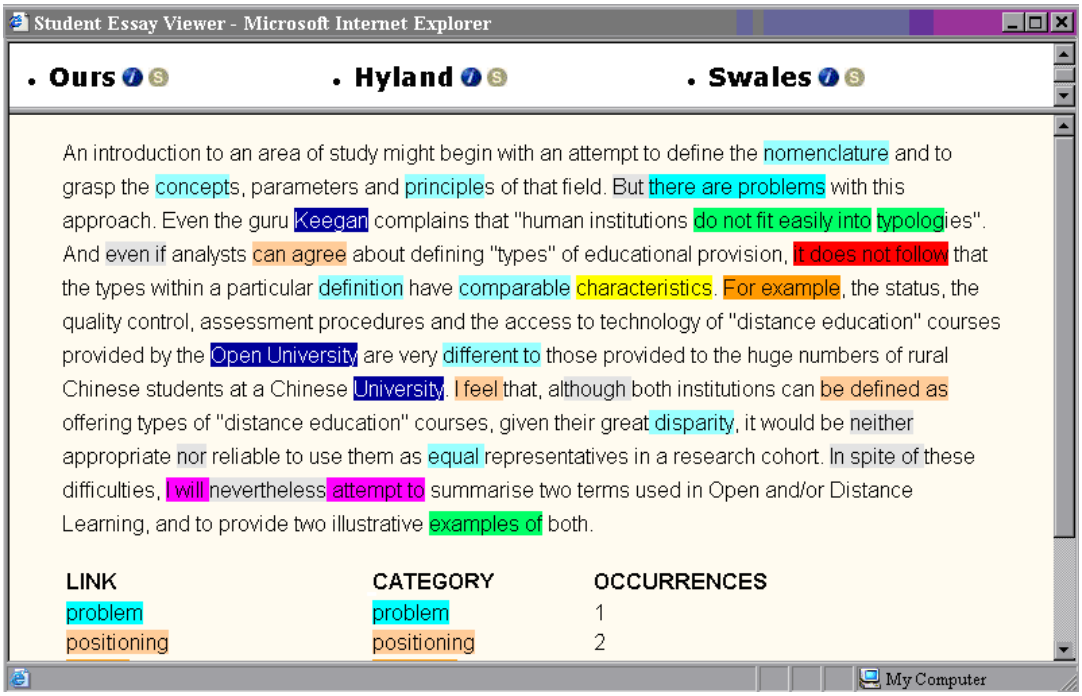

Figure 6. Simple User Interface displaying annotated essay (using "Ours" categorisation)

The Student Essay Service (SES) allows visualisation of instances of argumentation categories within an essay, in a shallow version of "making thinking visible". The intuition is that essays with considerably more "highlighted text" contain considerably more argumentation – and actual "content" – and therefore are likely to attract higher grades (and be better essays) than essays with little highlighting.

In the e-learning scenario, SES annotates essays using argumentation categorizations stored as ontologies. Of course, subscribing to ontologies defining alternative argumentation schemas can provide further annotation flexibility.

The output of the SES (i.e. annotated text) would then be optionally (but fruitfully) combined with a visualisation of these annotations (provided by the Visualisation service) for the user to inspect. The exact look-and-feel would depend on the User Interface: Figure 6 shows a simple HTML-based visualisation of the annotations. At the top, the available argumentation categorizations can be explored. The main part contains the essay: this is initially displayed without any annotations. However, when a category is selected, the annotations relating to this category are displayed. Selecting a whole categorization causes annotations relating to all its categories to be displayed (each colour corresponding to a different category, middle section of Figure 6). Below the essay, a count of links of each type is displayed for reference (bottom of Figure 6). An optional visualisation could be displayed even further down (or in a separate window, depending on user's preferences). Annotations could be saved in XML or RDF format.

Student Essay Service and its Role in e-Learning

The role of SES in e-learning services architecture is evident: it can be used to give students feedback and it could even (eventually) be used to aid assessment. Visualisation of its annotations in particular could be useful to tutors who may refer to its automatic counts indicator, citation highlighting or simply use it to quickly gauge the amount and distribution of argumentation cues across an essay. Tutors, being "essay experts", approach the marking of an essay with a clear idea of what it should contain. SEV helps them quickly ascertain to what extent that essay matches their expectations and makes essay comparison in terms of argumentation (links) less time-consuming.

SES could also be used to provide formative assessment to students. Students are well advised to revise their essay before submission if not much argumentation was found. An improvement in the essay (more background and reasoned argumentation to match the question) should result in more highlighting. This may increase motivation in some students.

SES is based on some assumptions concerning the relationship between annotations and essay quality:
1) "Bad essays" generally have a lower number of annotations than better essays (i.e. are less "content-rich");
2) Critical analysis and background reviews are two essential elements in most essays. These annotations are expected to be the most important in terms of association with the human-assigned score;
3) The relative importance of annotation categories within an essay may vary across essays types.

In previous work, we tested these hypotheses and found them to be true to a certain extent (Moreale and Vargas-Vera 2003).

Table 7. Examples of Essay Questions

Question Asks…	Assignment	Example
Summary + How and Why	Ass 1, part 2	"In the light of Otto Peter's ideas… say how each type can or cannot serve these ideas and why"
Opinion about X	Ass 2, part 1	"Who do you think should define the learners' needs in distance education?"
	Ass 4, part 3	"State and define your views on the questions of whether the research is adequately addressing what you regard to be the important questions or debates"
3. Describe + Discuss	Ass 2, part 2	"Imagine you are student and your teacher has a strong leaning towards the technical-vocational orientation. Describe and discuss your experiences, using concepts and examples from text book 1."
	Ass 4, part 2	"Define and discuss any cultural factors you observe in relation to each of these questions"
Give example of X and Critique X	Ass 4, part 1	Provide examples of web links covering a wide range of choose aspects of open and distance education and write a short critique of each.

Annotation Categories and Essay Questions

Query classification gives information about the kind of answer our system should expect. The classification phase involves processing the query to identify the category of answer being sought. In particular, sentence segmentation is carried out: this reveals nouns, verbs, prepositions and adjectives. The categories of possible answers, which are listed below, extend the universal categorization of traditional question answering systems (by adding to the six categories: what, who, when, which, why and where). We have so far applied SES to four different assignments. Our analysis of the essay questions in our testbed (see Table 7) showed that they were answered by essays with different “link profiles” (see Table 8).

The basic idea is that, depending on the essay question, we expect to find a different “distribution” of links in the essay themselves: e.g. a question asking for a “summary” is usually answered by an essay containing many “reporting” links. Table 8 matches essay questions with our essay metadiscourse categories.

Table 8. Examples of Essay Questions and Expected Links

Example of Question	**Links Expected to be Important**
Summary of X + How and Why	Essays answering such questions have a high number of the following link types: reporting, positioning, expected, is about, part and contrast.
2. Opinion about X	Essay has a high number of background, expected names, positioning. However part link does not seems very relevant
3. Describe and Discuss	Describe and Discuss essays feature a high number of support and positioning links. In the case of assignment 2, part 2, there was a low number of reporting links, as students were asked to describe a hypothetical situation; however, this may not always be the case.
4. Give an example of X and Critique X	In these essays, analysis and summative connector links are higher than “is about” and “contrast” links.

We then took all essays for assignment 1 and 2 (93 in all) and focused our attention on “link profiles” (Tables 8, 9): in particular, what link profiles could reasonably be expected in a satisfactory essay written for assignments 1 or 2. We performed a statistical analysis on the data (obtained from the 35 essays for which we had the required grade breakdown) to test our hypotheses. The results of this analysis are summarized in Table 9.

Table 9. Expected/Actual Argumentation links (Assignments 1 and 2)

ID	**Expected**	**Results**	**Analysis**
Ass 1 Part 1	Many reporting links	- reporting links count significant ($r=0.730$; $N=12$; $p<0.01$) - positioning links count not significant - total link count significant: $r=0.624$; $N=12$; $p<0.05$ $F(1,10)= 6.385$; $p<0.05$	Spearman correlation and ANOVA F-statistic seems to support our expectations: reporting links are more important than positioning links in this type of essay.
Ass 1 Part 2a	high number of reporting, positioning and expected links.	reporting more important than positioning statistical significance for “specific reporting links”: a) “Peters” $r=0.744$;$n=12$;$p<0.01$ b) “Peters+industrial+ODE” $r=0.717$;$n=12$;$p<0.01$ $F(1,14)=6.524$; $p<0.05$	Some students, while including sufficient reporting /expected links, managed to wander off topic (and hence their grade was not high). Better grades achieved by essays that stayed “on topic” (“specific reporting” links)
Ass 1 Part 2b		significant correlation between score and specific reporting links: $r=0.526$;$n=15$;$p<0.05$ ($r=0.586$ excluding “Holmberg”) no statistical significance for generic reporting or positioning links expected not significant	Many students wandered off topic (discussed around Holmberg / expected stuff but not enough on guided didactic conversation or GDC). Hence, only reliable indicator is specific reporting links.
Ass 2 Part 1	positioning links important	positioning links show a significant correlation with score: $r=0.538$;$n=20$;P,0.05	When background is not “at the forefront” in an essay question, positioning tends to be the determinant link type.
Ass 2 Part 2	-reporting (especially reporting on Schön)	- reporting links (generic): Spearman’s Rho: 0.467; $n=20$; $p<0.05$; -specific reporting links $r=0.541$; $n=20$; $p<005$; - word count: $r=0.639$;$n=20$;$p<0.01$	Reporting links are important in this kind of essay, particularly links directly connected to the question (students sometimes tended to wander off topic). Word count is important, again, as this is the last part in Ass2 and some students overran their target in part 1.

While positioning links are determinant in Assignment 2 part 1, overall, the importance of reporting links is apparent: essays at graduate and post-graduate level nearly always (at least in part) require showing that one has "done the reading". Where reporting links were not significantly correlated with grade, this seems related to students wandered off topic (e.g. they talked about Holmberg and his ideas at length, but did not spend most of their time and words on guided didactic conversation, something the question specifically asked about).

This suggests that – in order to detect if an essay is answering the question (i.e. not going off topic) – SES should make use of both a "generic" reporting link category and a more specific one ("specific reporting links" in Table 9). Examples of cues used for "specific reporting" in Assignment 1 part 2a were: Peters, industrial and Open & Distance Learning. In our specific e-learning scenario, specific reporting instances could be derived from query classification techniques (such as sentence segmentation) applied to the specific essay query and then revised by the tutor.

Student Essay System and Feedback

Students are often unclear about what exactly should go into a particular essay or get "side-tracked" and use too many words covering one aspect of the essay (e.g. background) at the expense of others (e.g. positioning). SES could help by alerting students to a lack of certain types of argumentation. Such a warning would be created when the link profile does not match the one set up by the tutor for the specific essay. For instance, if the question requires justifications or asks "why" and "how" questions, the tutor may have chosen to specify that the essay is to contain considerable "positioning" argumentation and therefore an essay containing mostly background material but little positioning argumentation will not be a satisfactory answer to the essay question. SES would therefore report this to the student.

Conclusion and Future Work

The main contribution of this paper is our outline architecture for e-learning services in the context of a semantic portal, the description of various scenarios within this architecture, including enrolment in a course and annotation of a student essay. We have used ontologies to describe learning materials, annotation schemas and ontology of services.

Our architecture moves away from the traditional teacher-student model in which the teacher determines the learning material to be absorbed by students and towards a new, more flexible learning structure in which students take responsibility for their own learning, determine their learning agenda, including what is to be included and in what order. As well as having more choice, students also have wider access to semantic technologies such as annotation tools. At the other end of the spectrum, tutors are freed from the task of controlling the delivery of learning materials (which is now controlled by the student) and their role focuses more on the production of materials that stand on their own by being properly annotated so that they can be located in the correct contexts by semantic services.

We have implemented a service that performs question answering and one that carries out argumentation annotation in student essays. A feedback service could then use the essay question (possibly in the form of tutor-determined settings) to determine what categories are expected to be prominent in an essay and alert the user if a relevant category is missing or under-represented. This will give students valuable clues as to whether they are answering the question correctly.

There is clearly a lot more work needed to make this technology work well enough for large-scale deployment.

Further work may include implementing and evaluating a functional version of the portal with the components described here. More functionality could then be implemented or even simply be provided by invoking services made available elsewhere on the Web. This would be a further step towards a really open system that realises the goal of a Semantic Web.

In short, this paper has presented a proposal for a distributed e-learning architecture comprising several e-learning services. Possible services include question-answering, online courses, tutoring systems and automated marking systems. Currently, two components have been developed. One is AQUA, a question-answering system that looks for answers in different resources. The second component is a student essay service, which uses a metadiscourse annotation schema for student essays. A visualisation service then also provides a visualisation of annotation categories relevant to the current question types. All the functionality described here is only part of what a full-fledged student semantic portal may eventually offer in the future but it is an important first step towards a really student-centered educational environment.

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Semantic Description of Educational Adaptive Hypermedia based on a Conceptual Model

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Abstract

The role of conceptual modeling in Educational Adaptive Hypermedia Applications (EAHA) is especially important. A conceptual model of an educational application depicts the instruc-tional solution that is implemented, containing information about concepts that must be ac-quired by learners, tasks in which learners must be involved and resources that will be used. The importance of such a model is multifold. It formally depicts the outcomes of instructional analysis, drives the development of actual applications and provides the information basis for automatic application generation in the context of Adaptive and Intelligent Tutoring Systems. In this paper we begin by describing a method for designing EAHA. Our method uses UML as the modeling language and defines the design process in three distinct steps. We propose an RDF encoding of the Conceptual Model, which is the outcome of the first step, following a specific RDF schema that is appropriate for such applications. This encoding can be obtained automatically and, in this way, a machine processable semantic description of the EAHA becomes available, as an outcome of the design process. In the resulting RDF-encoded Concep-tual Model, we define rules of adaptation using the existing language RuleML.

Keywords

Adaptive hypermedia, hypermedia design, conceptual modeling, semantic web, RDF

Introduction

Educational Adaptive Hypermedia Applications (EAHA) provide personalized views of Educational Hypermedia to individual learners. They are gaining the focus of the research community as a means of alleviating a number of user problems related to hypermedia. However, despite the growing interest of the community and the increasing number of available systems, the actual impact of these systems in e-learning remains low. The difficulty and complexity of developing such applications and systems have been identified as a possible reason for this low diffusion of Adaptive Hypermedia in web-based education.

The development of EAHA is a complex task engaging people with different backgrounds: instructional designers, subject matter experts, content developers, multimedia developers, user interface experts, programmers, etc. Experience from traditional Software Engineering as well as Hypermedia Engineering suggests that a model-driven design approach is appropriate in developing applications where such requirements and constraints occur. This approach has a number of benefits:

- It facilitates the communication of the various stakeholders involved into the development process.
- It captures and depicts high-level design decisions and solutions at various levels of abstraction. These decisions and solutions are not only related to implementation issues but also to higher-level concerns.
- It establishes a disciplined development process.
- It automates the development of the final product by using specialized tools.
- It provides an intuitive, easy to comprehend and understand view of the applications under development through applying visual modeling techniques. A design model can be derived from existing applications so as to describe their architecture, structure and functionality in a process known as reverse engineering.

Existing Software Engineering methods fail to deal with the particular requirements of hypermedia applications, their user interface intensive nature and their complex node-and-link structure. Although the discipline of Hypermedia Engineering (Lowe & Hall, 1997) emerged to address this issue, existing Hypermedia Engineering methods are not adequate for properly dealing with the design of educational hypermedia applications. While such models and methods have been successful in modeling the navigation and presentation issues, they fail to capture the abstract, conceptual issues of such applications. This results from the fact that traditional hypermedia applications are "information-oriented", that is, they consider the hypermedia-hypertext structure as a front-end for accessing structured information, usually stored in databases or other information systems. Thus, conceptual models of such applications provide models of highly structured information and a description of the business logic underlying these applications. Conversely, educational hypermedia applications - either adaptive or not - are not information- but learning-oriented. That is, the added value for a user of such applications is not access to information, but learning, as an outcome of planned instruction. Learning is the result of carefully designed activities and tasks, assessment procedures, selection of proper resources that will support these activities and procedures, that is, the outcome of instructional analysis (Smith & Ragan, 1999). Furthermore, existing Hypermedia Engineering methods cannot either capture the issues specific to adaptivity or describe the semi-structured nature of such applications and systems. Thus, designing Educational Adaptive Hypermedia is an open research issue (Brusilovsky & Maybury, 2002).

In (Retalis & Skordalakis, 2001) a method has been proposed, named CADMOS (CoursewAre Development Methodology for Open instructional Systems), that proposes a sequence of phases for the development of web-based educational applications. These phases are requirements capturing, design, implementation and evaluation. CADMOS has a specific component, named CADMOS-D, to support the design phase. We are in the process of extending CADMOS-D in order to support EAHA design. CADMOS-D, as a design method, provides two distinct models for educational web applications development: A *process model* (Lowe & Hall, 1999; Sommervile, 1997), that pertains to the detailed definition and specification of the various design steps, their temporal relationships and sequencing and a list of the outcomes of each step, and a *product model* (Lowe & Hall, 1999) that refers to the detailed specification of the outcomes of each step, capturing the design decisions, the relationships and dependencies between these outcomes and the mechanisms that allow these outcomes to drive the development of the actual application. Furthermore, the product model can form the basis for the description of existing applications, provide the blueprints that depict knowledge and common understanding for particular applications, either completed or under development, much in the way that the blueprints of a building can both drive its development and depict its form, structure and function.

While the process model of CADMOS-D has been left in its original form, the product model was updated in order to meet the requirements of adaptivity. The Unified Modeling Language (Object Management Group, 2003) has been used as a visual notation and modeling language for the design model of CADMOS-D. As it will be discussed later, the product model of CADMOS-D is separated into three sub-models: A Conceptual Model, a Navigation Model and an Interface Model. This is a widely adopted distinction in Hypermedia Engineering. In this way, the domain specific issues of the application are captured in the Conceptual Model. The connection between conceptual primitives and navigation elements such as pages and hyperlinks are depicted in the Navigation Model. Last, presentation issues such as styles, layouts, page templates, are depicted in the Interface Model.

This paper focuses on the Conceptual Model of EAHA, which is of particular importance for designing such applications. A conceptual model of an educational application depicts the instructional solution that is implemented, containing information about concepts that must be acquired by learners, tasks and activities in which learners must be involved and resources that will be used. The importance of such a model is multifold. It formally depicts the outcomes of instructional analysis, drives the development of actual applications and provides the information basis for automatic application generation in the context of Adaptive and Intelligent Tutoring Systems. It also reveals the internal structure of an educational application regardless of the technology used in any particular system hosting the application.

We provide an RDF encoding for the Conceptual Model of EAHA that are designed using CADMOS-D. More specifically, we first propose a UML meta-model that abstracts the conceptual models of all EAHA and we encode this meta-model in an RDF schema. Next, we propose an encoding for conceptual models of specific EAHA, i.e. instances of the previous meta-model, that can be obtained automatically given the corresponding UML diagram. Last but not least, we propose an encoding of the rules that implement adaptivity in EAHA using the existing language RuleML (http://www.ruleml.org). This encoding can also be obtained automatically, provided that there has been some formal specification of the adaptation rules in the original model, through rules in an appropriate language, e.g. OCL.

Through the encoding of the Conceptual Model of EAHA using Semantic Web technologies, we obtain a machine processable semantic description of EAHA, that can be produced automatically as an outcome of the design process. Whereas the other outcomes of the design process, e.g. the UML models, are only valuable for the developers of the EAHA, this semantic description is valuable in its own right, in parallel to the application itself.

The Semantic Web provides globally meaningful representations of concepts and their interrelationships that go beyond the scope of a particular system, application or organization. Furthermore, the information described using Semantic Web technologies, such as RDF or OWL, is organized in a form that permits automatic logic reasoning based on this information, involving Artificial Intelligence techniques. Although semantic web technologies are not the best candidates for conceptual modeling during the design process (e.g. as compared to a modeling language like UML), their adoption has a definite added value in the development of EAHA for the following reasons:

Design reuse

The Conceptual Model captures the decisions concerning the organization of the activities that the learners are involved in during their interaction with the application and the association of these activities to particular web-based resources in a particular application. These design decisions concerning a particular educational domain have a value of their own and can be reused. For example, a particular design of a tutorial on the subject of programming languages, i.e. the organization of the topics of study, the examples, exercises and tests taken by the learners compose a set of decisions that can be used by some author of another tutorial on the subject, regardless of the actual content that will be used for the development of the tutorial.

Formalization of the description.

The Unified Modeling Language is a visual, standard notation that was extended so as to describe the Conceptual Model of an EAHA. Apart from its certain advantages, namely intuitive presentation of the design decisions, ease of use, ease of communication, etc, UML inherently lacks a strict formalism. RDF, on the other hand, is a formal, machine processable notation. Furthermore, the basis for RDF all the Semantic Web descriptions is XML. This facilitates the integration of these descriptions with both UML (through XML Metadata Interchange – XMI) (OMG, 2003) and the existing learning technology standards which all have XML bindings.

Establishment of common understanding

In the conceptual model a specific distinction is made between high-level, abstract entities –*concepts* and *relationships*– and specific real-life objects such as *resources*. RDF semantics aligns well with this distinction, as it provides a basis for the creation of common language for expressing metadata with specific syntax and commonly agreed semantics.

Design sharing and retrieval

An RDF representation of the conceptual design of an AEHA provides a meaningful semantic representation of the subject domain as well as the strategies employed for the teaching of this domain. Furthermore, this representation is globally unique, has specific meaning and is machine processable. As a consequence, the resulting representations can be used by proper design tools that will contain proper search agents in order to provide the appropriate resources available on the Web for the designer. This search may be conducted to specific learning resource brokers or peer to peer networks such as Educanext (http://www.educanext.org/) and Edutella (http://edutella.jxta.org/), or more generic platforms for the management of RDF data, such as RDFSuite (Alexaki et al., 2001). Thus, both the *provision* and the integration of learning resources into an application are made possible.

As an example application, throughout the paper, we use a tutorial on Fire Safety. This tutorial was initially developed by the Emergesmart company (http://www.emergesmart.com) using the LRN Toolkit (Microsoft, 2003), a tool for creating and structuring on-line tutorials, that did not have any adaptive features. It was extended in order to sequence the activities offered to the learners according to their performance in specific tests. The IMS Simple Sequencing Learning Technology Standard (IMS, 2003) was used so as to formally specify the structure of the learning material and the conditions under which part of the material is selected and delivered to learners during their interaction with the tutorial.

The structure of this paper is as follows: In the following section, the CADMOS-D hypermedia design method is outlined. The product model for EAHA used by CADMOS-D is presented next. It is followed by a description of its encoding, using Semantic Web technologies, and a discussion on rules of adaptation and their possible encoding. The paper ends with some concluding remarks.

CADMOS-D: A Hypermedia Design Method

CADMOS-Design (CADMOS-D) is a method for the creation of the detailed design of web-based educational applications, which includes structural details of the learning resources, the navigational schema and templates for describing abstractly the graphical user interfaces. This method follows the principles of the Object Oriented Hypermedia Design Method (OOHDM) (Schwabe & Rossi, 1995; Schwabe & Rossi, 1998), which has provided a systematic way to design (generic) hypermedia applications.

The CADMOS-D method belongs to a web-based educational application (WbEA) development methodology named CADMOS. It proposes a stepwise design process model, as shown in Figure : Conceptual Design, Navigational Design and Interface Design. The intermediate products of each step are validated according to guidelines for formative evaluation of the instructional design (checking structural, navigational, aesthetics and functional issues). The whole design process is considered to be iterative, where in each iteration loop the design artifacts are evaluated and the feedback from the evaluation is used for their improvement, until they reach the desirable level of detail so that they can drive the actual implementation.

Conceptual Design

Although well known and widely used in hypermedia design, this step has a somewhat different purpose in the current approach. The Conceptual Design step aims at describing the abstract solution of the individual learning problem, which has been identified by instructional designers, subject matter experts or pedagogists into a systematic form that will guide the development of the actual educational application. This abstract solution is preferably defined as a set of learning objectives, instructional events associated with these objectives, the syllabus, and the assessment procedures (Retalis & Skordalakis, 2001; Ford et al., 1996). It is intended to facilitate the transformation of an abstract description of an educational application into a hierarchy of concepts to be taught. Each concept is related to particular learning objectives, notions and terms to be taught, etc. The hierarchy of organized concepts corresponds to the hierarchy of the terms, notions, intellectual skills, that the learner is to acquire via her/his interaction with an educational application under design. *Concepts* are notions to be taught using the specific application, as well as learner tasks or activities, described in an abstract manner, that facilitate the learning of these concepts or the achievement of specific learning objectives. Apart from their hierarchical organization, concepts can be associated with each other forming a semantic network that provides a conceptual view of the domain to be taught and the adopted instructional strategies. This particular view can be reused per se, thus promoting the reusability of educational applications at the level of the conceptual design, apart from navigation and presentation issues. In this way, the proposed method incorporates the principle of separation of concerns and promotes reusability. The designer defines this structure and specifies the particular *resources* associated to each concept. The concepts together with the associated resources align with the notion of Learning Object Metadata (http://ltsc.ieee.org/wg12/) associated to particular learning objects. These resources are considered as either static fragments of digital content, e.g. text, image, video, simulations etc, either as dynamic content generated 'on the fly' in the context of a web-based application environment (e.g. CGI, PHP, ASP, JSP, ColdFusion, etc) or Learning Management System. The concepts can be composite, if they contain other concepts, or atomic. The granularity of the resources is not specified.

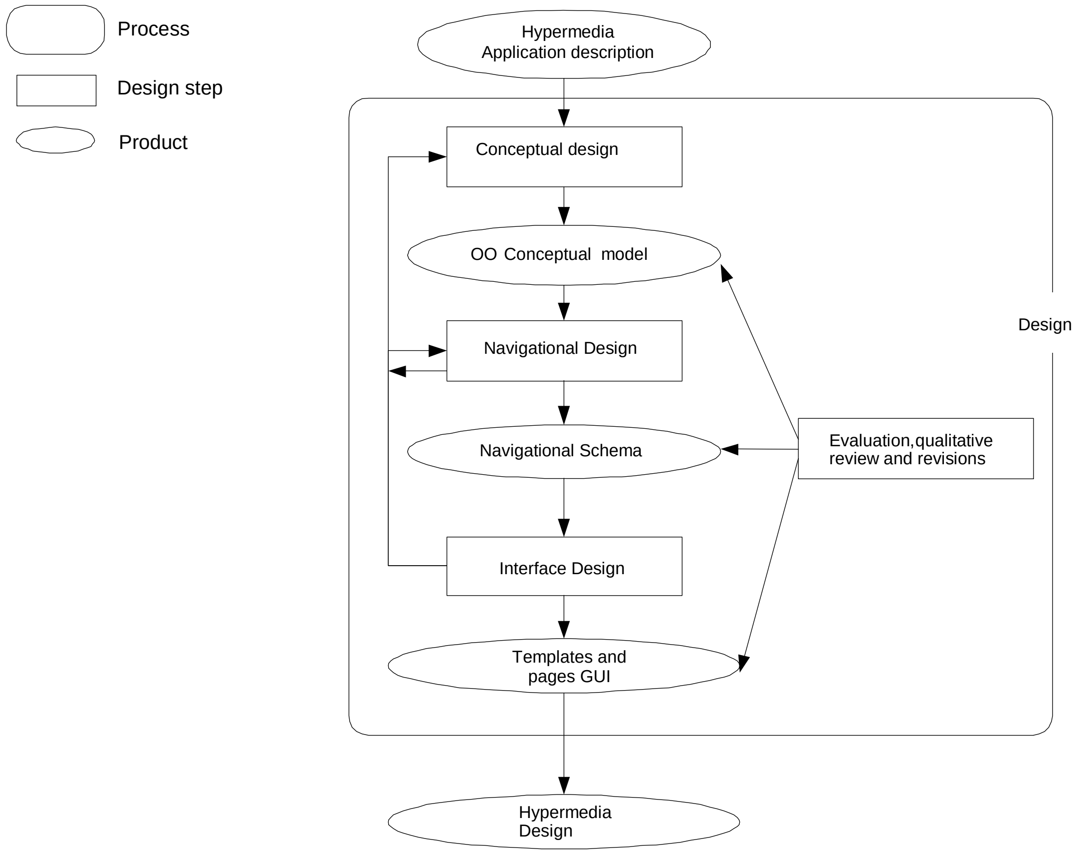

Figure 1. The three design steps in CADMOS-D

In this way, an anarchic aggregate of available, reusable, learning resources is structured into an organized mosaic according to the instructional design of the course. Note that the use of existing, reusable resources is not compulsory. New resources can be authored or implemented while developing a new application and can be integrated into the application during the conceptual design phase. The Conceptual Model is a set of UML class diagrams. For facilitating the construction of these diagrams CADMOS-D has proposed an abstract object oriented meta-model (Papasalouros & Retalis, 2002) which is independent of the underlying subject domain of the application (i.e. mathematics, geography, etc.) but provides a suitable platform to describe structural and navigational issues of the learning resources. This model constitutes the input for the next step, Navigation Design.

Navigational Design

In this step the navigational schema of the Educational Application is analytically designed, so that it is clearly specified how the previous structure of resources is transformed into web pages and how these pages are inter-connected with hyperlinks. More importantly it facilitates the maintenance of the web site, especially when web pages are added or deleted and hyperlinks to and from them have to be updated. In this way, the well-known problem of 'dangling' links can be avoided. The navigational structures proposed for this kind of design are well accepted by many hypermedia design approaches, such as HDM (Garzotto et al., 1993), RMM (Isakowitz et al., 1995; Isakowitz et al., 1997) and OOHDM (Schwabe & Rossi, 1995; Schwabe & Rossi, 1998). More specifically they are: a) indices that provide direct access to every indexed node, b) guided tours which are linear paths across a number of nodes and c) indexed guided tours which combine the two previous structures.

Interface Design

In this step, the Graphical User Interface (GUI) of the hypermedia application is designed, that is the content, layout and 'look and feel' of the web pages. Interface design is ruled by the principles of the *page metaphor*, a practice taken from multimedia engineering where it has been extensively adopted and used. The page metaphor is used to specify the page components with graphic symbols and deploy them on the screen showing their layout. Therefore, with the use of graphical semantics, the design depicts the page form just as it will be implemented. The data model for the interface design contains six kinds of page components: plain text, multimedia elements, active elements, hyperlinks, frames and form elements. The designs made are actually re-usable page templates. For instance, if we design the page template of one paragraph of an on-line book in a hypermedia application, then all the other paragraphs of the book might have the same look, using the same components with the same layout, have the same frames etc. During the interface design, except for designing page components and their layout, we define certain metadata on them.

Description of the design Model

The outcomes of the CADMOS-D process steps depicted in Figure constitute a product model for Educational Applications. We have extended this model towards the direction of adaptivity. The new product model follows the traditional approach in hypermedia engineering of separation of an application model into a Conceptual, a Navigation and a User Interface view or sub-model. These views describe the products of the corresponding design steps (see Figure). Furthermore, a Learner Model and a Teaching Model are provided in order to adequately describe the adaptive features of Educational Applications. An overview of the model components and their dependencies is depicted in Figure . Note that the Conceptual, Navigational and User Interface Models comprise the Hypertext Model and correspond to the outcomes (artifacts) of the three design steps of CADMOS-D, namely Conceptual Design, Navigational Design and User Interface Design.

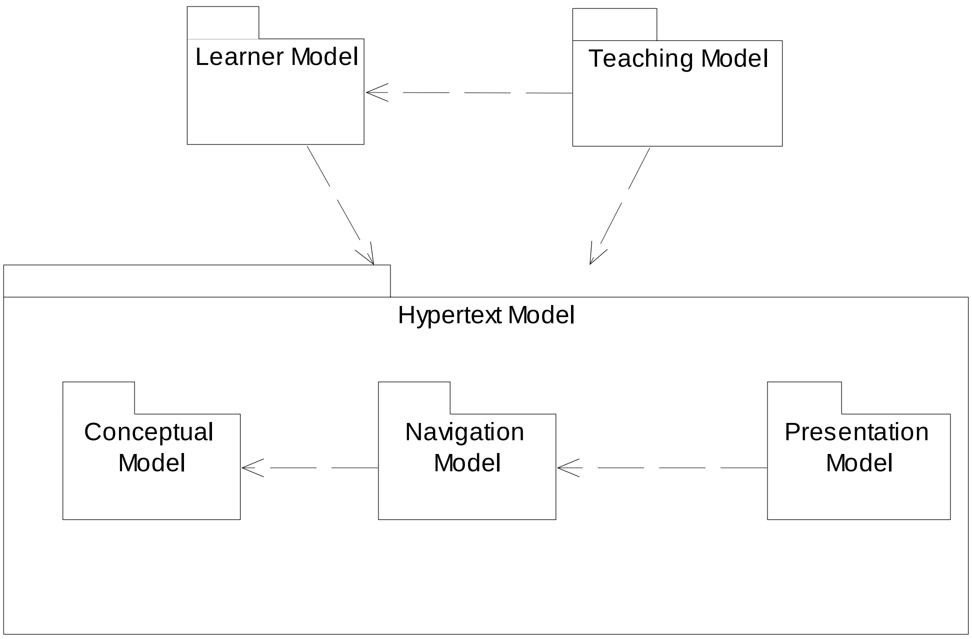

Figure 2. Overview of the Design Model

All the above models are expressed using the Unified Modeling Language. The language has been properly extended defining new modeling elements (stereotypes) and defining their allowed relationships for the particular domain of educational applications. The extensibility mechanisms of this language, namely stereotypes and constraints have been employed in order to define this extension by means of a UML profile (OMG, 2003).

The Conceptual Model

The Conceptual Model contains the basic concepts presented in the specific educational application together with their semantic interrelationships. These concepts are expressed as attribute-value pairs connected with specific associations. The elements of the conceptual model are associated according to the meta-model illustrated in Figure . Figure depicts the conceptual model of the Fire Safety Tutorial example application, which is an instance of the meta-model depicted in Figure . The concepts are mapped to specific learning resources. The modeling elements of this meta-model are:

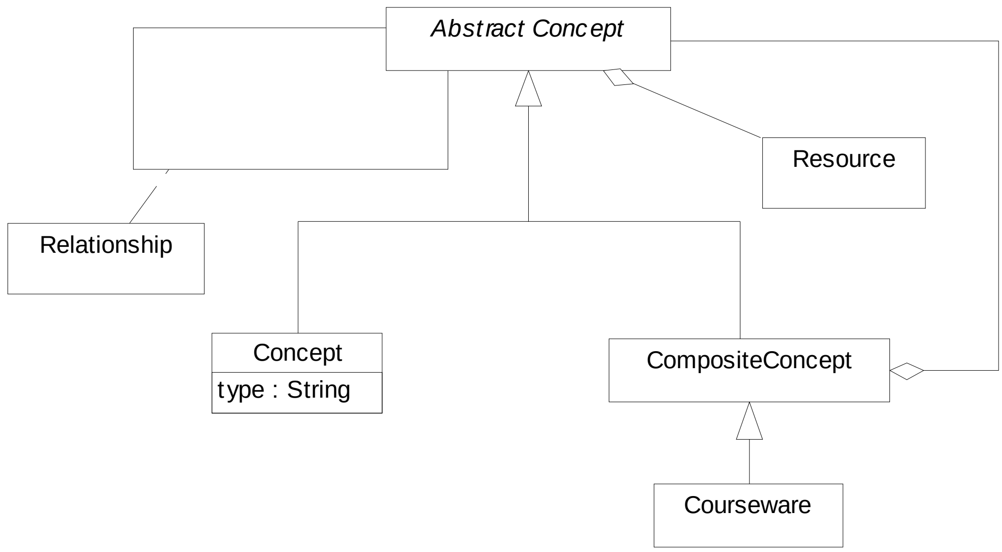

Figure 3. UML description of the Conceptual meta-model

Courseware

This is the top-level element in the hierarchy of concepts that compose the conceptual view of the application. In the example illustrated in Figure the top-level element is "Fire Safety Tutorial".

Concept

This defines a simple, atomic concept. This concept contains specific attributes. A concept can be a specific topic for study, an activity for assessment or dynamic interaction, simulation, etc. Note that this element refers to an abstract aspect of the specific entity as the result of instructional design. It does not correspond to any concrete media element that is contained into the specific application. A concept has a predefined attribute named *type,* which denotes the kind of learning activity it engages in, that is, gaining information, assessment, interaction with active elements, etc. An example of Concept shown in Figure is "Introduction", which is a concept of type "Information". This represents the instructional activity of introducing the learner to the subject of fire safety and presents the topics that will be discussed in the tutorial. Note that the instructional activity represented by this concept is independent of the learning resource (see corresponding element later in this section) that will actually implement this concept, e.g. text, video or other. Another example of Concept in the same figure is "Pretest". This is a concept of type "Assessment" and its purpose is to assess the knowledge of the learner.

Composite Concept

This element defines a composite concept, which contains other concepts, atomic or composite, thus forming a hierarchy of concepts into the educational application. It can be a chapter or topic containing other sub-topics. Using composite makes possible the organization of the learning activities into units of instruction such as, for example, sections, lessons, etc. “Types of Fire Extinguishers” is an example of a composite concept for the Fire Safety tutorial depicted in Figure .

Resource

A resource describes the actual media element that has been developed to provide a concrete, binary entity for a concept, atomic or composite. A resource is close to the notion of a reusable learning object, a chunk of information of arbitrary granularity that can be used in the development of an educational application or courseware. It corresponds to the notion of Learning Object Metadata widely used in the field of Educational Technology Standards. In the Fire Safety Tutorial the video file “Intro_video” is a resource that actually implements the “Introduction” informative concept.

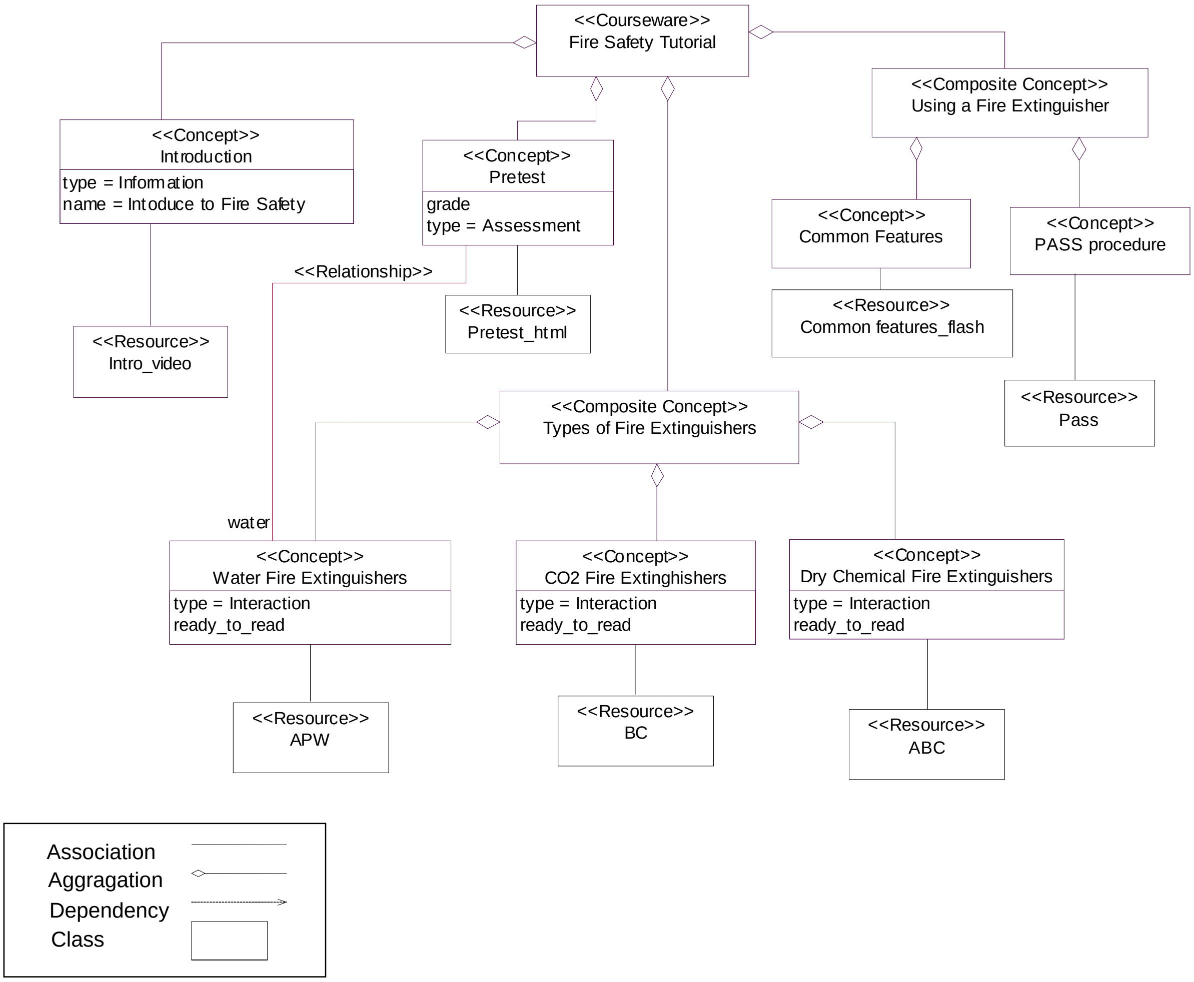

Figure 4. Conceptual Model of the Fire Safety Tutorial (Detail)

Relationship

This refers to the association between two elements, either concepts or resources. For example, two concepts can be connected with a relationship denoting that the one is an assessment over the other. In Figure , there is an association between concept “Pretest” and “Water Fire Extinguishers” meaning that “Pretest” assesses the knowledge on “Water Fire Extinguishers”.

The top-level element in the hierarchy of concepts is “Fire Safety Tutorial” which is the name of the actual educational application. This is represented in the same figure with the stereotype *Courseware*. Based on the solution of the instructional problem, this is decomposed into the following concepts, looking from left to right in the figure: “Introduction”, which presents an introduction to the tutorial in the form of a video. This video, namely, “intro_video.wmv” is described as a *Resource* element with the same name. Correspondingly, the concept “Pretest, is associated with the “Pretest_html” *Resource*. The composite concept “Types of Fire Extinguishers” is decomposed into three simple concepts, namely “Water”, “CO2” and “Dry Chemicals” Fire Extinguishers. These simple concepts are associated with the “APW”, “BC” and “ABC” resources, respectively, which are actually shockwave applications. The rest of the UML elements are self-explanatory.

The RDF description of the Conceptual Model

The Conceptual Model described above is expressed using the Resource Description Framework – RDF (Manola & Miller, 2003). The mapping between UML and RDF was based on Chang (1998). The RDF is a language for providing information about resources on the web. This information is provided as properly structured metadata about resources pertaining to specific application domains. For each domain, there is a need to establish a common vocabulary for the domain-related information of the resources. This is achieved using a language for defining specific RDF vocabularies, RDF Schema (Brickley & Guha, 2003). In this sense, RDF Schema is a meta-language, also expressed in RDF, for the definition of specific RDF bindings.

Our approach for the definition of RDF descriptions of specific educational hypermedia designs follows two steps: First, a Schema of the Conceptual Meta-model itself is provided in Figure . This is actually a slightly modified version of the meta-model described in (Papasalouros & Retalis, 2002). In this schema the basic elements of the conceptual model, i.e. the elements Concept, Relationship, Resource, etc, are defined as RDF Schema classes, while their predefined attributes are defined as properties of these classes. Note the *related Resource* property that relates *Concepts* to actual learning resources.

```
<?xml version="1.0"?>
<!DOCTYPE rdf:RDF [<!ENTITY xsd "http://www.w3.org/2001/XMLSchema#">]>
<rdf:RDF
    xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
    xml:base="http://www.softlab.ntua.gr/andpapas/schemas/conceptual">

    <rdfs:Class rdf:ID="Courseware"/>
    <rdfs:Class rdf:ID="Concept"/>
    <rdfs:Class rdf:ID="CompositeConcept"/>
    <rdfs:Class rdf:ID="Resource"/>

    <rdfs:Property rdf:ID="name">
        <rdfs:domain rdf:resource="#Concept"/>
        <rdfs:domain rdf:resource="#CompositeConcept"/>
        <rdfs:range rdf:resource="&xsd;string"/>
    </rdfs:Property>
    <rdfs:Property rdf:ID="type">
        <rdfs:domain rdf:resource="#Concept"/>
        <rdfs:domain rdf:resource="#CompositeConcept"/>
        <rdfs:range rdf:resource="&xsd;string"/>
    </rdfs:Property>

    <rdfs:Property rdf:ID="relatedResource">
        <rdfs:domain rdf:resource="#Concept"/>
        <rdfs:range rdf:resource="http://www.w3.org/2000/01/rdf-schema#Resource"/>
    </rdfs:Property>

    <rdfs:Property rdf:ID="Relationship">
        <rdfs:domain rdf:resource="#Concept"/>
        <rdfs:domain rdf:resource="#CompositeConcept"/>
        <rdfs:range rdf:resource="#Concept"/>
        <rdfs:range rdf:resource="#CompositeConcept"/>
    </rdfs:Property>

</rdf:RDF>
```

Figure 5. RDF schema of the Conceptual Meta-model

The RDF Schema in Figure does not describe the concrete design of any particular web-based application. It provides the basis for the formalization of conceptual model descriptions by providing the appropriate elements and their interconnections. Particular designs of educational applications constitute schemata that are based on the aforementioned one, being its refinements. In these designs new classes can be defined, based on the primitive classes of the generic Conceptual Model schema and new properties and associations can be assigned to these classes. This is slightly different from the UML approach, where specific designs are considered as *instances* of the classes of the meta-model and not its *subclasses* (refinements). Additionally, a design of a newer hypermedia application can be based on a previous one after being able to locate and reuse its ontology-based description. Furthermore, the same or different designer can provide different versions of an RDF-described conceptual model. Although not demonstrated in this article, these capabilities are provided by the inherent support for distributed knowledge representation provided by the semantic web technologies and by the evolvability of Web itself (Lee, 1998). In this way, the involvement of semantic web in representing specific designs leads to evolution rather than mere design reuse.

In Figure the RDF Schema of the Conceptual Design for the Fire Safety Tutorial described in the previous section is illustrated. In this schema, the generic classes *Courseware*, *Concept* and *CompositeConcept* are refined into application-specific classes such as *FireSafetyCourseware*, *PretestConcept*, *WaterConcept*, etc. For some of these application-specific classes, new properties are defined. For example, for the *PretestConcept* class a property named "grade" is defined, which expresses the grade that a student is assigned after taking a preliminary test for the Fire Safety tutorial.

```
<?xml version="1.0"?>
<!DOCTYPE rdf:RDF [
    <!ENTITY xsd "http://www.w3.org/2000/10/XMLSchema#">
    <!ENTITY conc "http://www.softlab.ntua.gr/andpapas/cadmos/conceptual#">]>
<rdf:RDF

    xml:base  ="http://www.softlab.ntua.gr/andpapas/cadmos/FireSafety"
    xmlns:rdf ="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
    xmlns:conc ="&conc;"
    xmlns:xsd ="&xsd;">

    <rdfs:Class rdf:ID="FireSafetyCourseware">
        <rdfs:subClassOf rdf:resource="&conc;Courseware" />
    </rdfs:Class>
    <rdfs:Class rdf:ID="IntroductionConcept">
        <rdfs:subClassOf rdf:resource="&conc;Concept" />
    </rdfs:Class>
    <rdfs:Class rdf:ID="PretestConcept">
        <rdfs:subClassOf rdf:resource="&conc;Concept" />
    </rdfs:Class>
    <rdfs:Class rdf:ID="TypesofExtinguishersCConcept">
        <rdfs:subClassOf rdf:resource="&conc;CompositeConcept"/>
    </rdfs:Class>
    <rdfs:Class rdf:ID="WaterConcept">
        <rdfs:subClassOf rdf:resource="&conc;Concept" />
    </rdfs:Class>
    <rdfs:Class rdf:ID="CO2Concept">
        <rdfs:subClassOf rdf:resource="&conc;Concept" />
    </rdfs:Class>
    <rdfs:Class rdf:ID="DryChemicalConcept">
        <rdfs:subClassOf rdf:resource="&conc;Concept" />
    </rdfs:Class>

    <rdf:Property rdf:ID="grade">
        <rdfs:domain rdf:resource="#PretestConcept" />
        <rdfs:range  rdf:resource="&xsd;integer" />
    </rdf:Property>
    <rdf:Property rdf:ID="ready_to_read">
        <rdfs:domain rdf:resource="#WaterConcept" />
        <rdfs:domain rdf:resource="#CO2Concept" />
        <rdfs:domain rdf:resource="#DryChemicalConcept" />
        <rdfs:range  rdf:resource="&xsd;boolean" />
    </rdf:Property>
    <rdf:Property rdf:ID="isTested">
        <rdfs:domain rdf:resource="#WaterConcept" />
        <rdfs:domain rdf:resource="#PretestConcept" />
    </rdf:Property>

</rdf:RDF>
```

Figure 6. RDF Schema of the Fire Safety Tutorial

The RDF Schema of the Conceptual Design of a particular application, like the one illustrated in Figure , can be automatically generated from UML models. These models, created using appropriate CASE tools and described in XMI format, can be easily transformed to RDF Schema descriptions using XSL Transformations (Clark, 1999).

The schema for the Fire Safety Tutorial provides the basic concepts and relationships for the educational application under consideration. Thus, it specifies the instance space for this application. An instance of it contains elements defined in the schema having appropriate values in their properties. An excerpt of such an instance is depicted in
Figure . Note that while the namespace prefix for the generic conceptual schema is “conc”, the namespace prefix for the elements of the Fire Safety Tutorial is “fireEx”.

```
    <!-- ... -->
    <!DOCTYPE rdf:RDF [
    <!ENTITY xsd "http://www.w3.org/2000/10/XMLSchema#">
    <!ENTITY fireEx "http://www.softlab.ntua.gr/andpapas/cadmos/FireSafety#">]>
    <!-- ... -->

    <fireEx:FireSafetyCourseware rdf:ID="#FireSafety">
        <conc:name>Fire Safety Tutorial</conc:name>
        <dcterms:hasPart>
            <rdf:Bag>
                <rdf:li rdf:resource="#Intro"/>
                <rdf:li rdf:resource="#Pretest"/>
                <rdf:li rdf:resource="#types"/>
            </rdf:Bag>
        </dcterms:hasPart>
    </fireEx:FireSafetyCourseware>
    <!-- ... -->
    <fireEx:PretestConcept rdf:ID="#Pretest">
    <conc:name>Pretest Knowledge on Fire Safety</conc:name>
    <conc:type>Assessment</conc:type>
        <fireEx:grade rdf:datatype="&xsd;integer">0</fireEx:grade>
        <conc:relatedResource rdf:resource="#pretest_html"/>
    </fireEx:PretestConcept>

    <fireEx:TypesofExtinguishersCConcept rdf:ID="#types">
        <conc:name>Present the Types of Fire Extinguishers</conc:name>
        <dcterms:hasPart>
            <rdf:Bag>
                <rdf:li rdf:resource="#Water"/>
                <rdf:li rdf:resource="#CO2"/>
                <rdf:li rdf:resource="#Dry"/>
            </rdf:Bag>
        </dcterms:hasPart>
    </fireEx:TypesofExtinguishersCConcept>

    <fireEx:WaterConcept rdf:ID="#Water">
        <conc:name>Water Fire Extinguishers</conc:name>
        <fireEx:ready_to_read rdf:datatype="&xsd;boolean">true</fireEx:ready_to_read>
        <fireEx:isTested rdf:resource="#Pretest">
        <conc:relatedResource resource="#APW"/>
    </fireEx:WaterConcept>

    <!-- ... -->

    <rdf:Description rdf:about="#APW">
        <dc:title xml:lang="en">
             Water Fire Extinguishers
        </dc:title>
        <dc:format>
            <dcterms:IMT>
                <rdf:value>application/x-shockwave-flash</rdf:value>
            </dcterms:IMT>
        </dc:format>
    <lom-tech:location
resource="http://www.softlab.ntua.gr/andpapas/cadmos/FireSafetyDemo#APW.dcr"/>
        <lom-tech:otherPlatformRequirements xml:lang="en">Shockwave</lom-
tech:otherPlatformRequirements>

<!-- ... -->
```

Figure 7. The RDF description of the Fire Safety Tutorial Conceptual Model (excerpt)

The aggregation of concepts, that is, the containment of concepts by others, is achieved by the use of the `dcterms:hasPart` element adopted by both the Dublin Core and IEEE metadata RDF descriptions. These descriptions were adopted in attempt to reuse existing standards in the proposed conceptual model.

In the RDF description of the Fire Safety Tutorial exemplified above, the actual resources are expressed using an IEEE LOM metadata description as proposed in (Nilsson, 2002). This facilitates the easy storage, search and retrieval of specific resources incorporated into particular applications. In this way, a specific RDF description of an application contains not only information about the structure of the application (design reuse), but also information about the actual learning objects that it has reused.

Rules of adaptation

The Conceptual Model presented so far, in both its UML representation and its RDF encoding, corresponds to the Domain Model component of the Adaptive Hypermedia Applications Model (De Bra et al., 1999). This, among others, also identifies a Teaching Model as the component that defines the actual rules of adaptation in the form of if-then-else rules applied to specific properties of the concepts of the Domain Model. In addition to the UML description of the Conceptual Model, we define rules of adaptation that correspond to the Teaching Model, which are expressed using the Object Constraint Language (Warmer & Kleppe, 1999). More specifically, certain rules are expressed as *invariant* conditions, that is, logical expressions that must always evaluate to true in order for the model to be in a valid state. An example of an invariant condition is given below. This is applied to the "Pretest" concept in Figure , as it is determined by the keyword `context`.

```
context Pretest inv:
        this.grade = 5 implies water.ready_to_read = true
```

This condition states that if the performance of a student in the pretest is five out of five, expressed in an attribute of name `grade`, then the interaction concept "Water Fire Extinguishers" is considered as ready for study by the particular student. The two concepts are connected with an association in Figure and the word `water` expresses the *role* of the "Water Fire Extinguishers" in the given association. Note that this rule defines a specific instructional design strategy for teaching the specific topic of Fire Safety. This strategy is described abstractly and is not connected to any implementation concern, for example navigation or user interface. These concerns are dealt during later phases of design according to CADMOS-D.

In the rest of this section we present how the Teaching (or Rules) Model can be encoded by appropriately applying rules to our RDF-based conceptual description of Educational Adaptive Hypermedia. Again, these rules only express instructional decisions, that is, they only refer to teaching strategies concerning the specific domain, e.g. the sequence of activities to be performed by the learner given his/her performance assessment activities.

We propose the use of the Rule Markup Language, or RuleML, for the application of specific rules in the elements of the RDF encoded Conceptual Model. RuleML is an "XML-based markup language that permits Web-based rule storage, interchange, retrieval, and firing/application". This language is intended to provide rules on Semantic Web OWL and RDF ontologies.). We are currently developing a tool for the translation of OCL rules to RuleML to facilitate the automatic transformation of UML models to Semantic Web descriptions beside XSL Transformations.

The same rule expressed earlier in OCL is expressed in RuleML as shown in Figure 8.

The syntax of RuleML is based on Horn clauses (Horn, 1951). The head *atom* is evaluated to "true" if all the atoms in the *body* section are true. Thus, the above expression means that "if variable *concept* is of type *WaterConcept*, variable *pretest* is of type *PretestConcept*, *concept* is tested by *pretest* and the grade of this concept has value *5*, then the *WaterConcept* property *ready_to_read* is *true"*. Note that here we only provide the syntactic basis of the rules involvement in creating adequate ontologies for describing adaptive educational applications. The semantic implications, e.g. the types of rules (event-condition-action rules, constraints, etc.) are considered to be handled by specific implementations and they are not treated here. This is only a semi-formal notation for the description of certain instructional design decisions that pertain to adaptivity.

Other examples of rules could be the update of the knowledge about learners represented in the User Model (Brusilovsky, 1996) of an Adaptive System, according to their history of interaction with the educational application or their performance in assessment activities.

```
<imp>
  <_head>
    <atom>
      <_opr><rel &fireSafety;#ready_to_read"</_opr>
      <var>concept</conc>
      <ind rdf:datatype="&xsd;boolean>true</ind>
    </atom>
  </_head>
  <_body>
    <and>
      <atom>
        <_opr><rel rdf:resource="http://&fireSafety;#WaterConcept"/></_opr>
        <var>concept</var>
      </atom>

      <atom>
        <_opr><rel rdf:resource="http://&fireSafety;#Pretest"/></_opr>
        <var>pretest</var>
      </atom>

    <atom>
        <_opr><rel rdf:resource="http://&fireSafety;#isTested"/></_opr>
        <var>concept</var>
        <var>pretest</var>
        </atom>

       <atom>
        <_opr><rel rdf:resource="http://&fireSafety;#grade"/></_opr>
        <var>pretest</var>
    <ind rdf:datatype="&xsd;integer>5</ind>
      </atom>
    </and>
  </_body>
</imp>
```

Figure 8. Expressing a rule using RuleML

Conclusions

In this paper we have presented how the outcomes of the Conceptual Design stage of a method for developing Educational Adaptive Hypermedia Applications can be encoded using RDF-based ontologies. Initially, the Conceptual Model is documented using the Unified Modeling Language, which is a more suitable representation for the human developers of EAHA. However, the proposed encoding of the Conceptual Model has certain benefits, such as reusability of design, formalization of the description and use of emerging technologies for the sharing of information based on the semantic web.

These descriptions can be automatically derived from existing UML models. However there is no need for a specialized UML tool for this purpose. UML models created by using existing CASE tools such as the IBM Rational Rose (http://www.rational.com) and described in XMI format can be easily transformed to RDF descriptions using XSL Transformations. Currently, we apply adaptation rules in UML models using OCL. We are developing a tool for the translation of OCL rules to RuleML to facilitate the automatic transformation of UML models to Semantic Web descriptions beside XSL Transformations.

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Malaysian Perspective: Designing Interactive Multimedia Learning Environment for Moral Values Education

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Abstract

The field of education is faced with various new challenges in meeting with the demands of teaching and learning for the 21st century. One of the new challenges is the call for the integration of ICT (Information and communication technologies) in teaching and learning as an alternative mode of instruction delivery. Multimedia technology for instance, has the potential in transforming traditional classrooms into a world of unlimited imaginary environment. This paper reports on a research project on development of an interactive multimedia courseware package for moral values education using traditional Malay oral narratives called CITRA. CITRA uses CD-ROM and the computer as a means of dissemination. It is a didactic tool created for the teaching and learning of good moral values in an interactive multimedia environment. It is made up of four learning modules: Storytelling World module, Enjoyable Reading World module, Word Enrichment Corner module, and Mind Test Land module. The tool's most important feature is its user interaction capability. The principle objective of this project is to create a pedagogical tool that combines on-screen text, graphics, animation, audio and video in an enticing environment and thus enables the positive values and images of stories to be projected.

Keywords

Interactive multimedia, Traditional Malay oral narratives, Storytelling, Moral values, Education

Introduction

Multimedia technology is one of the most exciting innovations in the age of information. The rapid growth of multimedia technology over the last decade has brought about fundamental changes to computing, entertainment and education. The exponential growth of multimedia technologies and applications has presented society with unprecedented opportunities and challenges. Educational multimedia courseware and applications are in many ways similar to printed textbooks and other teaching and reference materials in that they come in a wide range and variety. Some multimedia applications are broad and comprehensive while others are more focused. Applications either address introductory and advanced students or teachers and scholars of particular subject areas. The potential of interactive multimedia in the learning environment is well-recognised world wide, as evidenced by various projects funded by universities, schools, government bodies and private organisations.

Today greater demands are being placed on education systems at all levels to produce citizens who can apply knowledge in new domains and different situations. With the gradual increase in the integration of computer and multimedia technology in educational activities, there is a need to consider not only the unique opportunities they bring to learning and learners, but also the benefits that may be derived from their use. However, a majority of the teaching-learning courseware available in the Malaysian market focuses on subjects such as Malay language or Bahasa Melayu (our national and official language), English, Chinese Language, Mathematics, and Science. Therefore, there is a need for computer-aided learning materials in educational activities, which can provide students with practice and foster moral values at the same time.

It can be observed that there is an emphasis on the importance of ICT in the social and economic development of a country at the expense of moral values. Toffler (1984) notes that developed nations are facing moral degradation and breakdown in the family institution. Lee Lam Thye, a renowned Malaysian activist states "Economic and technological development must not be at the expense of moral and human development which is crucial to enable us to cope with the many social maladies besetting our society" (Juhana, 2001). In addition, the former Prime Minister of Malaysia, Tun Dr Mahathir bin Mohamad points out that:

> “This country must develop in total in all aspects that encompass racial unity, social, and economic integration, political stability, administration system, quality of life, social and spiritual values, national pride and self confidence” (Nappie, 1991).

It is thus crucial that the development of moral values is in consonance with the development plan of the Malaysian government - Vision 2020. Vision 2020 launched by the Prime Minister of Malaysia, Tun Dr Mahathir bin Mohamad in 1991, is a comprehensive 30-year plan ensures that Malaysia becomes a developed nation in the new millennium. Today’s children are the ones who will realize Vision 2020. Society is responsible in instilling good and positive moral values in the children within the framework of religion and culture. One of the means of fostering good moral values is through storytelling. Honesty, diligence and tolerance are some of the best motivating elements needed in the development of personalities and good behavior in children, which can be taught through stories.

Fittro (1997) postulates that children develop morality slowly and in stages. Each stage brings a person closer to mature moral development. Fittro also notes that one of the effective ways to help our children turn their moral reasoning into positive moral behavior is to teach by example. However, children are surrounded by bad examples. What can we do to ensure that our children will grow up with love and integrity? Besides setting a good example for children, one of the simplest things we can do is to read a story to which they can relate to that illustrates a principle or value (Custom made children stories, http://www.teachingvalues.com/custommade.html). Every culture in the world seems to create stories (narratives) as a way of making sense of the world. Storytelling, one of the oldest forms of folk art, takes children on an enthralling journey and at the same time instructs them in history, culture and moral values. The moral values within the stories have as much relevance today as in the past. The stories can be effectively used as starting points for discussions on issues of personal right and societal values. Storytelling is a valuable teaching tool in an outcome-based education classroom. It can effectively assist in the acquisition of literacy, numeracy and life skills in the foundation phase and provide a valuable resource for language learning and teaching at both primary and secondary levels of schooling. Stories can be used by teachers in their classrooms as a source of supplementary reading. Storytelling also develops learners' creative skills by stimulating their imagination. According to Mhlophe (The Teacher/Daily Mail & Guardian, 2000), storytelling is about the theatre of the mind. It allows children to set free their imagination.

Today, besides traditional books, computers provide a new means of presenting literature to children. Computer can be the vehicle for presenting stories to children on CD-ROM or to evaluate children on stories that they have read. In addition, with access to the Internet, computers can be a means of learning more about literature and serve as a vehicle for sharing ideas with others. Multimedia is suitable in presenting stories to children for it facilitates learning and enjoyment of stories. For the purpose of multimedia courseware development, popular traditional Malay oral narratives comprising six humorous tales, three edifying tales and two animal tales, were selected for this project. These stories expose children to both positive and negative values in life.

Statement of the Problem

The colonization of Malaysia by the British tremendously affected traditional Malay oral narratives. Boehmer (1995) defines colonial literature as a general term in reference to concerned with colonial perceptions and experience, colonial expansion, the superiority of European cultures and the rightness of empires, which are written incidentally during colonial times. Boehmer points out that colonized peoples were represented as less human, less civilized, as infants or savage, a wild man, animal, or headless mass in contrast to the superiority of an expanding Europe. This influence could have also affected portrayals of ancient Malay society in traditional Malay oral narratives. Malays are seen as foolish, lazy, a glutton, greedy, delinquent, and so forth in well-known foolish antics of the simpleton Pak Pandir, Pak Kaduk or the escapades of Pak Belalang. According to H. Ahmad (1997), the stories also contain positive and didactic elements, which however had been reduced to a lesser degree. Thus, in the present study, multimedia is used to project positive images and didactic elements of traditional oral narratives to foster positive perceptions toward the stories in children and to instill good moral values.

Software profit-making and curiosity-seeking potential have largely ignored educational software as a potential market. It is because the investment in the education field is limited. Therefore software development is seldom related to education although software development has grown rapidly in recent years. Software developments were mostly related to business or are games-oriented applications. (Meziane et al., 1999). Besides, most of the multimedia-based educational software available in the Malaysian market focuses on the major teaching subjects such as Bahasa Melayu, English, Mathematics, and Science. Thereby, the effort for developing computer and multimedia-based educational applications locally, which can help to foster good moral values in children.

Software developments in storytelling especially with ones local content and in the vernacular language are scared in the Malaysian market. The market of storytelling software is dominated by imported software which popularizes their traditional narratives such as “Snow White and The Seven Dwarfs”, “Cinderella”, “Sleeping Beauty” and so forth. As a consequence, our younger generation is more exposed to foreign narratives than to local narratives. A survey on 397 secondary school students aged 13 to 16 shows that there are more respondents who know stories of Cinderella (68.5 %), Beauty and The Beast (42.1 %) and Snow White and The Seven Dwarfs (38.5 %) than those who know stories of Legenda Mahsuri (18.1 %), Si Tanggang (20.5 %) and Bawang Putih Bawang Merah (13.3 %). Moreover, the sources of local traditional narratives such as Puteri Gunung Ledang, Nakhoda Tanggang and Batu Belah Batu Bertangkup are limited. Malaysia is rich in its oral tradition, however not much of it has been popularized. The amount that has been published is still very modest. Youngsters are still relying on foreign literature, which contains alienating elements that are not appropriate for our local culture. The positive values in social, moral, and religious education can be fostered in the young through reading materials with local content. In addition, most of the imported software are in the native language. Given that the medium of instruction in a majority of Malaysian schools is in the Malay language or Bahasa Melayu, so there is a need to have more storytelling software in this language, which contains local literature such as traditional oral narratives.

A majority of children have encountered stories even before they start school. Children are told stories by their parents and other significant people in their lives (Weinberger, 1996). Today’s, society wherein parents lead busy lives and thus do not tell stories to children, the impersonal communication media of films and television take the place of parents in entertaining children (Julongo, 1992). It is thus important to increase the production of the media form of storytelling. The art of oral storytelling by professional or amateur storytellers is gradually disappearing in modern life, but it still survives in the Malay villages. Many old people are reluctant to tell those tales because they assume that they are of no use to the present generation. They fail to realize that a rich cultural heritage will be irrevocably lost if those tales are preserved. The traditional oral narratives in Malay culture can be preserved only when they have been put into writing. For example, the stories concerned with a manikin mouse deer called “Sang Kancil” stories are popular not only for the Malays society, but also for the whole community of Malaysia. The stories about “Sang Kancil” have been recorded down from oral tradition, but they are known to have existed in manuscripts. Malaysia is rich in its oral tradition, but not much has been popularized. The amount that has been published is still very modest. Many more tales can be brought to light if collectors are diligent enough to track them down. Since traditional oral narratives represent a rich literary heritage from the past, they have to be preserved in writing or media form. Therefore, the collection or recording of traditional narratives especially using sophisticated technology such as multimedia is much needed to prevent these traditional narratives from extinction and to make making the tales accessible to a wider audience (Mohd. Taib Osman, 1988)

Based on Ambigapathy’s survey, the average of Malaysians read only half a page in a year, which is a rate far below the UNESCO leisure reading recommendation of 80 pages per person per year. Many Malaysians do not even read a single newspaper every day (Ambigapathy, 1997). Besides, according to a literacy survey carried out in Malaysia (Halimah, 1998; Munir, 2001), approximately 30 percent of the children studying in secondary schools are illiterate. Realizing this problem, there is a need for a research into a suitable program to promote literacy skills and to cultivate people to read especially at an early age. The reading habit should be instilled at a young age and this can be done through various pre-reading activities such as storytelling and writing. The activities or modules built into CITRA may assist children in acquiring literacy skills and in cultivating learning and reading habits

Storytelling in Multicultural Malaysian Society

The focus of the paper is on the tradition of storytelling among indigenous groups in Malaysia: the Malays and the Proto-Malays or Orang Asli. In preliterate Malay society, traditional oral narratives such as myths, legends and folktales belong to the oral tradition, which have been transmitted through time by means of oral narratives in countless generations. Unlike modern forms of literature, which are the creation of individuals, such narratives do not belong to anyone, but to the whole community. They are social manifestations, which believed to be related to nature. They also relate aspects of culture such as the belief system, world-views and social values of society (Md. Salleh Yaspar, 1985; Mohd Taib Osman, 1988).

The carriers of the tales are known by many different names, but play similar function -- they are storytellers who are able to enthrall their listeners with marvelous tales. The common term used to describe the storytellers in Malay society was what is technically termed a "Penglipur Lara" or the "Soother of Cares" (Mohd Taib Osman, 1988: 139). Specific names were also given to the storytellers in certain states of Malaysia. The storytellers of Perlis and Kedah are often referred to as "Awang Batil" or "Awang Belanga" who relates stories to the accompaniment of the beating of metal bowls of pots in rhythm with the storytelling. A unique characteristic of "Awang Batil" or "Awang Belanga" is that he puts on different masks for each character of a story he assumes. In Kelantan, the storyteller is called "Awang Selampit" or "Tuk Selampit" and he recounts his tales to the accompaniment of a rebab (a two-stringed bowed instrument). The storytellers are not merely entertainers, but they are also the carrier of moral teachings and wisdom and the provider of wondrous visions beyond the mundane and harsh world (Mohd. Taib Osman, 1982).

Radio, television and the cinema have a profound effect on Malay village life. In some areas, however, traditional forms of entertainment such as storytelling, wayang kulit (shadow play), and berdikir or hadrah (chanting) have continued to thrive with vigour. This shows that the traditional arts and pastimes still have a place in the life of Malaysian society. Oral traditions have continued to exist, although to a lesser degree than before as reflected in the collections by Dewan Bahasa and Pustaka (Language and Literary Agency), the students from the local universities and individual collectors (Mohd. Taib Osman, 1988). At present, Malay traditional narratives are either in oral recorded or in written forms. However, the presentation of traditional Malay oral narratives in media or digital form, especially in the vernacular language, is still limited.

Storytelling in Digital Age

Every culture has its share of a rich history of storytelling in oral, visual, textual, and digital form. The tradition of oral storytelling exists in the days when radio, television, and other information and communication technologies were unknown. It is an art to tell a story through the medium of voice. Oral storytelling was the only way of communicating before the advent of the written word. Wagamese (1997) states that the oral storytelling tradition is the process by which a culture's myths, legends, tales, and lore are formulated, communicated and preserved in language by word of mouth. The art of the oral tradition encompasses such essential considerations as memorization, intonation, inflection, precision of statement, brevity rhythm, pace and dramatic effect.

Digital storytellers are artists and writers who are passionate about combining the ancient arts of storytelling with the new and powerful tools of multimedia technology. Practitioners of this art form include anyone concerned with producing creative work on a computer and who has a high appreciation for the narrative arts such as poetry, storytelling, theater, fiction, essays and film (Mullen & Lambert, 1999). These storytellers use new tools and techniques such as HTML hypertext linking for the Web, animation programming in Macromedia Director and digital movie making with Adobe Premiere to tell their stories (Hitchcock, 1997). With the advent of digital storytelling, storytellers – both professional and amateurs are learning to use new technology to share their stories.

Digital storytelling offers an enhanced level of communication flexibility, multi-medium distribution, interactivity, freshness and engagement:

1. Non-linear flexibility: Digital stories are produced in separate modules. Thus, the storyteller has the option, based on audience feedback, to genuinely respond to the specific interests of the audience. Taking control of the presentation, the storyteller tailors each in-person presentation to respond to the interests of that particular group. Similarly, on the Internet, visitors can view only those modules that they think are of interest, and then respond in kind with a multimedia story of their own.
2. Multi-medium distribution: Digital stories can be both broadcast and narrowcast via multiple media including Internet, Intranet, CD-ROM, DVD, VHS, television, as well as right off one's laptop.
3. Interactivity: Digital stories provide the quiet time in between story modules that permit real-life storytelling, audience feedback and a respondent flow of new information based upon audience input.
4. Freshness: Digital stories, because of their computer-generated nature, can be updated easily and quickly. Sometimes in a matter of just hours a digital story can be refreshed with new video, photos, graphs and audio.
5. Engagement: Digital storytelling provides the ultimate medium for employing creative storytelling technologies and techniques. The result is in content that doesn't just entertain, but engages the audience.

Hence, the authors adopted this approach in design to develop an interactive multimedia learning environment for children to foster moral values in education.

Designing and Developing CITRA

The package of interactive multimedia courseware, CITRA (Courseware development to project positive values and Images of TRAditional Malay oral narratives), was developed in this study is based on various pedagogical approaches and learning theories deemed suitable for children age 8 to 9 year-old. According to Piaget (Crain, 1992), children at the age of seven to eleven can develop the capacity to think systematically. The design and development of CITRA was based on a well-researched conceptual framework (Fig. 1).

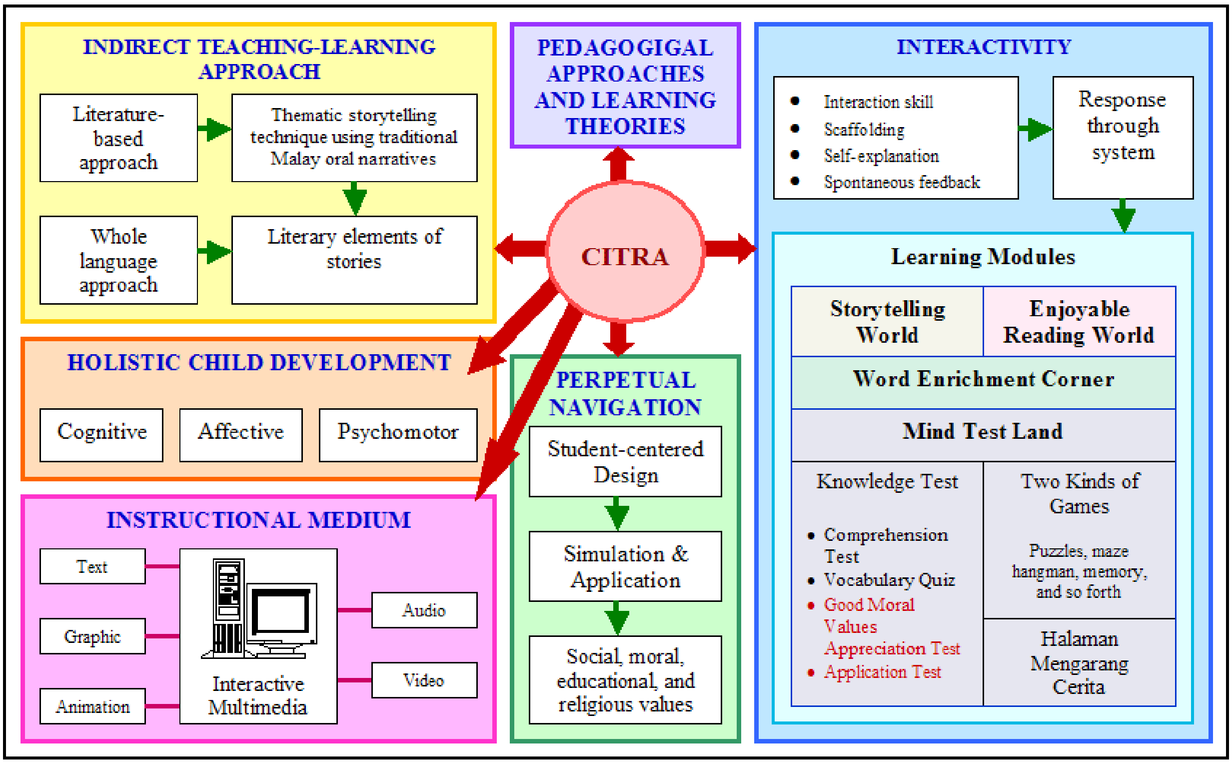

Figure 1. Conceptual Framework of CITRA

The design of content and activities in CITRA was also made using the experience from other systems and from education, Malay literature and ideas of ICT specialists. CITRA is designed and developed as a multimedia based tutoring system that not only incorporates various media, but also various teaching and learning strategies based on sound pedagogical theories. This ensures that the package developed can eventually assist children to understand the stories and foster positive moral values more effectively and expeditiously. As can be observed from the conceptual framework in Figure 1, it incorporates a number of elements. The elements are

Indirect Learning Approach

The stories are delivered through an indirect learning approach namely the thematic literature-based approach, to involve the learner in mind and spirit. Literature in this context means local literature based on traditional Malay oral narratives. Literature or stories are chosen since the story response approach brings another dimension into moral development, that of story development. Many researchers in moral education have adopted this narrative approach- influencing curriculum through a story-response approach. Through interacting with stories, children are given the opportunity to reason out such things as cause, effect and consequences, and to consider moral choices, and to also use the word of a story as a mirror for their own life experiences (Menz & Dodd, 2003). In addition, through stories, children are exposed to a wide range of challenges: it offers them an opportunity to widen their past experiences and develop new ones; it affords the unfolding of the pleasures of language; it furnishes a cognitive understanding of human behavior; it expands life experiences; and it yields a sensitivity to the use of languages as an important tool in coming to terms with human experiences (Ruddell, 1992). Using local content and vernacular language in developing CITRA is an important issue because teaching and learning becomes more effective when the content suits the local culture and way of life, hence learners can identify and relate themselves to the courseware.

In addition, it is developed based on the whole language approach in that children can learn reading more effectively. The whole language approach is chosen as storytelling is adaptable to this approach. Whole language is a term that has gained increasing interest within education in the past two decades. What is whole language? Bergeron (1990) defines the term as follows:

> Whole language is a concept that embodies both a philosophy of language development as well as instructional approaches embedded within, and supportive of, that philosophy. This concept includes the use of real literature and writing in the context of meaningful, functional and cooperative experiences in order to develop in students' motivation and interest in the process of learning.

Goodman (1992) states "Whole language aims to be an inclusive philosophy of education. Language (as well as oral), learning, teaching, curriculum, and the learning community are elements that involve in whole language". Whole language has an influence in various trends in education. According to Wood & O'Donnell (1991), reading instruction is moving towards more process orientation, which stems from cognitive psychology, and focuses on more literature-based instruction rather than the product-orientation instruction that is rooted in behavioral psychology related to basal-reader programs. In the professional literature, whole language is widely viewed as a theory of knowledge as well as a theory of language, learning and schooling. The whole language views language as a whole and not in discrete units.

Holistic Child Development

The holistic approach takes into account the literacy experience of the child, which assists in the cognitive, affective and psychomotor development of the child. "Cognitive" refers to the aspects of children thinking, including knowledge, understanding, application, analysis, synthesis, and evaluation by children. "Affective" is the capability to receive, respond and determine values. Finally, "psychomotor" refers to children's physical movement or physical activities based on what they have learnt. The modules developed in the model contribute to the three aspects of holistic child development.

Instructional Medium

Multimedia is chosen as an instructional medium to present the content of CITRA. The stories with integrated various literary elements are presented not only in text, but also in graphic, audio, video and animation. Multimedia has a lot of different connotations and definitions vary depending on the context. In the context of education, interactive multimedia is defined by three criteria: (1) Interactive multimedia is any package of materials that includes some combination of texts, graphics, still images, animation, video and audio; (2) The materials are packaged, integrated and linked together in some way that offer users the ability to browse, navigate and analyze the materials through various searching and indexing features as well as the capacity to annotate or personalize the materials; and (3) Interactive multimedia is always "reader-centered". In interactive multimedia, the reader controls the experience of reading the material by selecting among multiple choices, choosing unique paths and sequences through the materials. One of the key features of interactive multimedia is the ability to navigate through material in whatever ways are most meaningful for individual users (Bass, 2000).

In this present study, multimedia plays an important role in projecting the intrinsic positive values of traditional Malay oral narratives. What criteria should be applied when evaluating literature for children? How can multimedia play its role in projecting the positive elements? Answers to these questions emerge when we learn to recognize and evaluate such literary elements as theme, plot, characterization, setting and other literary elements such as mood, tone, style, and embedded moral values. These elements contribute to the overall appeal of a story. So, before the process of courseware development commenced, the authors had read critically the selected stories to identify positive and negative elements integrated in the stories. Some of the stories may have to be manipulated in certain literary elements to project the positive images. For example, literary elements in Pak Pandir tales that need to be manipulated in order to project the positive values and images are plot, characterization, and language style. The authors attempt to draw the audience's attention from Pak Pandir to his wife, Mak Andeh. Pak Pandir was known as 'Father Folly' who is a numskull. Through his slow-wittedness he produces silly actions that arouse laughter. On the contrary, Mak Andeh is intelligent, patient and tolerant. Through the admonition of Mak Andeh towards Pak Pandir’s foolish actions, the didactic elements are presented.

Pedagogical Approaches and Learning Theories

The appropriate pedagogical approaches and learning theories play a vital role as a basis of CITRA development. It incorporates a variety of pedagogical approaches and learning theories to meet diverse learning styles of children. Designing CITRA for fostering moral and values education needs greater effort in the presentation of the content since this will partly determine the success of the learning process. According to Shiratuddin & Landoni (2001), it is important to carefully design the way content is structured, organized, and presented. The types of activity in which the users will be involved play significant roles in the success of pedagogic designs. Based on the pedagogical approaches and learning theories, the modules of the model was designed and developed based on children’s capability.

Perpetual Navigation

Navigation in an information space involves the learner’s movements toward some learning goal or information retrieval task. It is clear that one method of making navigation easier is to carefully structure the knowledge contained in the information space. Like the layout of a good textbook, the careful sequencing of the material helps navigation through the corpus of information (Eklund & Sinclair, 2000). Perpetual navigation is the aspect of interface, which is designed for the learner-centered environment. With multimedia, navigational and participatory features provide more flexibility and control to the users. These unique features allow them to quickly access information when they need it. The learner is given more control over what and how s/he wants to learn. This transmission of information is done via the different modalities like sight, sound and touch, which is it allows learning through the most natural means - the senses. All-important icons based on the existing modules of the courseware are constantly presented on the screen. Although not all of the icons are activated, nevertheless they remain on the screen to enable the learners to know where they are at and where they can navigate to next. Users become participants in an exciting experience involving the sensory modalities of sight, sound and touch, all of which naturally facilitate learning. CITRA then incorporates simulation and application in teaching and learning to assist learners in exploring different aspects of subject matter (values of social, education, moral, religious, etc.) that is instilled in the courseware.

Interactivity

Interactivity within the program includes the use of active texts, buttons and icons linked to definitions, further information, other modules and so forth. Through interactivity that adopted in the four learning modules, the children practice good moral values.

CITRA merges the idea of stories with multimedia functionality to produce dynamic and flexible software to exercise thinking while acting, playing, exploring, navigating, and having fun. CITRA explore new horizons in the use of stories as a mean for helping young learners construct and reconstruct their thinking structures. CITRA may be seen as the electronic version of conventional literary stories. CITRA, which uses the CD-ROMs and computer as the means of dissemination, is a didactic tool made up of four key modules:

1. Storytelling World Module

Storytelling World or Dunia Mari Bercerita was the name given to the first module. This module incorporates a variety of media such as audio, graphics and animations in presenting the stories. It introduces the children to various kinds of traditional Malay oral narratives. The focus of this module is to project the positive values and images of stories using digital storytelling technique. Besides fostering good moral sense in children via projected positive images and moral values, it also allows children to practice and promote their comprehending and listening skills.

2. Enjoyable Reading World Module

Enjoyable Reading World or Alam Baca Ria was the name given to the second module. This module is developed based on the whole language approach which enables children learn reading more effectively. The whole language philosophy has been developing since the early 70s. Whole language as a reading strategy has gained popularity in recent years. Generally, the emphasis of whole language approach is on looking at words as wholes. Based on this approach, children are taught to read not phonetically but by meaningfulness of the word. Children will learn to discriminate the words through pattern recognition and then try to encode and decode the words. When the words are sounded by the system and children find them meaningful, they are able to remember the whole word better. The words chosen for the stories, which adopted the whole language approach, are based on the natural language of children age 8 to 9. Besides integrating audio, graphics and animation in presenting the stories as shown in Storytelling World module, this module also encompasses text. This is the different between the first and second module. In addition to projecting positive values and images, this module is able to motivate children and cultivate reading habit indirectly due to the multimedia approach and tutoring strategies of scaffolding, self-explanation and hyperlinks provided in this module. The words and sentences used are easily understood and are based on children's reading ability. This module also adopted interactivity and perpetual navigation approaches. Children can interact with the system.

3. Word Enrichment Corner Module

The third module included in the application is the Word Enrichment Corner or Sudut Pengayaan Kata. The difficult words or vocabularies as identified in the stories are reinforced and made meaningful to the children through text, graphics and audio in this module. For certain words, a motion video-in-a-window is attached to present the explanation, which makes the children understand the vocabulary better. This module is hyper-linked to Enjoyable Reading World module, in which the word or vocabulary is found. The learner can also retrieve the word or vocabulary using the quick search menu. It assists the children in understanding the story and appreciating the good moral values more effectively. The main objective of developing this module is to enrich the children's vocabulary.

4. Mind Test Land Module

Mind Test Land or Taman Uji Minda was the name given to the final module in CITRA. Four activities that adopted the problem solving, interactivity and perpetual navigation approaches are built into this module. The four activities are Knowledge Test, two kinds of games and Creating Story activity.

There are four different tests or quizzes built into the Knowledge Test: Comprehension Test, Vocabulary Quiz, Good Moral Values Appreciation Test and Application Test. The Comprehension Test and Vocabulary Quiz are designed and developed with the objective of testing and evaluating the children on their overall understanding of story and words presented in the previous learning modules. Children themselves can thus monitor their achievement and performance based on the feedback acquired from the tests or quizzes. The Good Moral Values Appreciation Test and Application Test focus on the presentation and evaluation of moral knowledge. Good Moral Values Appreciation Test is designed based on the Malaysian curriculum of primary school moral education. The moral values infused into the curriculum are of affective and emotional domains. It has been emphasized that some moral values need to be instilled into all children, so that they can achieve overall and balanced development. There are sixteen good moral values infused into the curriculum of moral education. They are: (1) compassion, (2) self-reliance, (3) respect, (4) love, (5) freedom, (6) courage, (7) physical and mental cleanliness, (8) co-operation, (9) diligence, (10) moderation, (11) gratitude, (12) rationality, (13) public spiritedness, (14) humility, (15) honesty, and (16) justice. Each moral value entails a number of sub-values respectively. However, not all the values and sub-values are integrated in a story. Therefore, before the process of CITRA development commenced, the authors had read critically the selected stories to identify positive and negative elements, and good moral values integrated in the stories. Good moral values that have been identified in a story and their sub-values will be explained briefly. Then only sub-values that embedded in story will be putting a question to the learner. Besides, the Application Test aims to evaluate and reinforce the moral sense of children that relates to their real life experience. The Good Moral Values Appreciation Test and Application Test intend to furnishes a cognitive understanding of human behavior, expand life experiences and yield a sensitivity sense to the use of moral sentiments as important tools in coming to terms with human experience. Meantime, the children can practice and promote their affective skills via the tests.

The next two activities built into the Mind Test Land module are various kinds of games such as jigsaw puzzle, sliding puzzle, memory game, maze game, hangman game, tic-tac game riddles, and so forth. These activities allow children to practice and promote their cognitive and psychomotor skills. The final activity in the Mind Test Land module is the Creating Story activity. This activity is instilled in the module with the aim to enrich the children's literacy experience and to motivate creativity sense in children. The activity allows children to compose their own stories based on the available graphics. This module can stimulate creative writing and allows children to write humorous or thought-provoking stories in a fun environment. It is believe that creative writing can be supported and encouraged through this activity.

Overall, the Mind Test Land module adopts the holistic child development approach that takes into account the literacy experience of the child, which assists in the cognitive, affective and psychomotor development of a child. It aims to reinforce the children's literacy and reading skills, promote and practice their thinking skills through activities related to the theme of the stories, and help to foster the cultivation of moral sentiments.

Creation of CITRA and Future Work

Many multimedia technologies are available for the researchers to create CITRA, an innovative and interactive multimedia application. These technologies include Adobe Photoshop, Adobe Premier and Snagit to create and edit graphics and video files respectively, SoundForge and Macromedia Flash to create or edit sound and animation files, respectively. CITRA development is done using a Macromedia Director authoring environment. Macromedia Director is chosen to be the primary authoring tool to integrate and synchronise all the media elements that have been created or modified and stored digitally in the computer into one final application for the purpose of conveying a specific message to the audience. Elements of interactivity and perpetual navigation are incorporated to involve the user in the application and to create a multi-sensory experience. CITRA then is packaged into a distributable format for the end-user. CITRA inevitably has large file sizes. Therefore, it cannot be accommodated by floppy disks, but by multimedia-capable optical storage devices. The researchers will save these multimedia applications as standalone presentations for CD-ROM delivery.

The development of CITRA is in 2D animation form. Future researchers are encouraged to do further research using 3D animation engines. The virtual reality (VR) and combination of VR and Artificial Intelligent (AI) to produce a mixed-reality (MR) application can be installed in the courseware. Virtual technologies will make the courseware more attractive to children and enhance the process of learning.

Conclusions

Stories are an integral part of human life. Stories are also something that we learn from others and we teach to others. The stories delivered to children should inculcate politeness and a sense of duty and honour. The interactive multimedia courseware reveals an interesting and exciting tool for teaching and learning. It may be used in class as a demonstration tool. On an individual basis it helps to reach pedagogic goals. In conclusion, we suggest that an additional feature for children's interactive multimedia application would be to present content by mixing different presentation modes and including various activities that support as much intelligence as possible. The interaction is the key feature and consists of quizzes, games, animation, etc. This project currently is at the stage of data analyses and courseware refinement. Finding of the study would be able to address some teaching and learning issues, in particularly the uses of interactive multimedia in stories for moral education.

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Teaching Petri Nets Using P3

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Abstract

This paper presents Petri net software tool P3 that is developed for training purposes of the Architecture and organization of computers (AOC) course. The P3 has the following features: graphical modeling interface, interactive simulation by single and parallel (with previous conflict resolution) transition firing, two well-known Petri net analysis tools (Reachability tree, Matrix equations), as well as two new analysis tools (Firing graph, and Firing graph) developed for learning purposes. The special aspect of the P3 is the XML/XSLT-based support for model sharing with the following Petri net tools: DaNAMiCS, Renew, and Petri Net Kernel (PNK). This paper also gives overview of the AOC course, and compares students' outcomes in the AOC course when they used the P3, with the previous course outcome when the students did not use P3. Finally, the paper shows how teachers (i.e. we) and students perceived P3's features.

Keywords

Petri net teaching, hardware teaching, simulation-supported learning, XML-based interoperability

Introduction

Petri nets are mathematical formalism intended to be used for modeling, simulation and analysis of different kinds of systems (Peterson, 1981). In computer science Petri nets are used for modeling a great number of either hardware and software systems, or various applications in computer networks. A special advantage of Petri nets is their graphical notation, which reduces Petri nets learning time and simplifies their use. Hence Petri nets are used for teaching numerous concepts in computer science (Jeffrey, 1991). We should note that some authors (Denning, 2000) say that experimental methods in computer science have frequently lead to important developments in both theory and practice. Constructing models and performing simulation on them, are the core issues in experimental methods (Desel, 2000).

Considering these Petri net features within a course of Architecture and Organization of Computers (AOC) at Military Academy in Belgrade, one could notice that they are used for modeling different concepts included in this course: control unit organization, arithmetic-logic unit organization, organization of buses, elements of multiprocessor communication as well as hardware modeling and measuring performance of computer systems (Stallings, 2000). We use the Upgraded Petri nets (Štrbac, 2002) that are developed in order to enable use of Petri nets for hardware modeling, as well as to provide modeling at register level. During the realization of the AOC course, a need to use adequate software has occurred.

Firstly, in this paper we give an overview of the AOC course curriculum and emphasize how we use Petri nets in this course. Then we present the P3 – a Petri net tool developed for teaching Petri nets within the AOC course (Gašević & Devedžić, 2003). Our main intention is to provide better software support for Petri net's education since we have a limited number of classes for introducing Petri net concepts. The basic idea of this approach is to provide simulation-supported learning Petri net concepts, as well as speeding-up Petri nets learning process to the level required for their use in the AOC course. The P3 has XML-based model sharing capabilities. Actually, the P3 uses the Petri Net Markup Language (PNML) – on-going Petri net community effort for a standard Petri net model interchange format (Billington et al., 2003). We have developed three eXtensible Sylesheet Language Transformations (XLST) in order to transform PNML that P3 exports to the formats of the following Petri net software tools: DaNAMiCS, Renew, and Petri Net Kernel. We have also implemented a XSLT that converts PNML to the Scalable Vector Graphics (SVG). In that way we enable teachers to create Web-based Petri net learning materials using the P3 (i.e. the P3 is a kind of authoring tool). We analyze the P3 tool through subjective students' and teachers' experiences. Students' opinions were obtained from a questionnaire students had at the end of the AOC course.

Course of Architecture and Organization of Computers

P3 tool was developed with an aim to be used within the AOC course. In the previous course realization forms we have found that, the tool support they were based on, was inadequate since the curriculum of the AOC course has limited number of classes planed for introducing Petri nets. Besides, we wanted to parallelly introduce computer architecture concepts to our students and to show them Petri net models of those concepts. The AOC course is for the 4th year undergraduate students of computer engineering. This course is a natural extension of the previous course in computer architecture – Basics of computer engineering. Besides computer engineering, our students have also good knowledge of electronics, digital electronics, and software engineering. While creating curriculum for the AOC course we were following recommendation given in (Cassel et al., 2001).

In Table 1 we show the AOC course structure. Firstly, we introduce Petri net concepts since we want to use Petri net in all course lectures. In the Petri net introductory lecture we present Petri net definition, Petri net graph, Upgraded Petri net definition, and common Petri net analysis tools (e.g. reachability, invariants). Then, we lecture computer architecture concepts and give Petri net models to explain formal verification for these concepts. Our main focus in Petri net modeling are exercises where students solve computer architecture problems using Petri nets. They need to use different Petri net analysis tools to verify their models. In that way, they learn practical value of having formal verification tools in hardware design. But, very often it is not enough to use only one Petri net software tool to obtain satisfactory solution. Further more, as we have already mentioned, we should have Petri net tools that can be used for learning and understanding Petri net analysis tools. Of course, Petri net tools should have advanced simulation and analysis features, since in the AOC course we also show a few real-world examples (Wilson et al., 1993). In that way we avoid over-simplifying instruction. In the next section we explain Petri net tools we have used in the previous AOC course realizations as well as mention obstacles that guided our decision to develop a new Petri net tool.

Table 1. Structure of the course Architecture and organization of computers in which P3 is used

Lecture	**Lecture tag**	**Number of hours**		**Petri net models**
		Lecturing	**Exercises**	
Petri net introduction	–	2	–	–
Processor architecture	1	5	5	2
Processor implementation	2	5	5	2
Arithmetic	3	6	5	2
Memory organization	4	6	5	2
I/O subsystem organization	5	6	5	3
Busses	6	3	2	3
Multiprocessor systems	7	3	2	4
Vector and matrix processors	8	3	2	4
Elements of distributed systems	9	3	2	5
Modeling and measuring of computer performances	10	3	2	3

Current Petri Net Tools

There are many Petri nets software tools (PNTDB, 2003). Three of them – DaNAMiCS, Renew and Petri Net Kernel (PNK) – we have used in the previous course realizations. Here we describe their features as we have perceived them during realization of the AOC course. The graphical user interface for modeling is a common feature of these three products. Although these tools offer extensive possibilities for Petri nets modeling, they do not provide detail explanations if it happens that a model contains a syntax error (e.g. arc between two places). With such notifications, learning process would be more effective. Concerning the simulation support, the three programs have interactive execution based on a single transition execution. However, a parallel execution would be useful as a teaching support, since it could help students to understand principles for defining priorities in conflicts states, as well as it could provide explanation why some simulation step can not be made although the marking state is fulfilled. Only DaNAMiCS implements analysis tools, but it does not have the capability to interactively map results to the observed model. That restrains the possibility of using DaNAMiCS for learning Petri nets analysis algorithms.

From these observations we concluded that for our purposes, it would be necessary to develop a new application. The following facts support this conclusion:

1. None of the three Petri nets software products implements the Upgraded Petri nets that are suitable for hardware modeling at the register level.
2. It is necessary to implement a new tool for model analysis that will be suitable for understanding model execution and conflict state analysis in order to eliminate them. A Firing graph has been developed for these purposes. Its details are presented later in this paper.
3. Although there are different publicly-available Petri nets software tools, we have implemented a new one in order to support teaching requirements of the AOC course from the very beginning.
4. We have not found any Petri net software tool that is extended with a support for transformation of its model format to the formats of other Petri net tools. For that purposes we suggest the XML/XSLT-based approach.

The P3 Architecture

The P3 is developed according to the facts we have given in the previous section. Further more, since the P3 is based on the PNML concepts, it is compatible with the PNML. We identified main parts that are related to the Petri net use. These parts are as follows:

- *Petri net structure* – The central part of the Petri net structure is a Petri net that consists of the Petri net basic concepts: places, transitions, and arcs (Murata, 1989). Petri net places and Petri net transitions can be generalized as Petri net nodes. Important part of the Petri nets that pertains their structure is marking (token current state of a Petri net), and initial marking. Although these Petri net concepts are not formally a part of the Petri net structure, they could be implemented as a part of the Petri net structure (places). Since we implement software tool that supports Upgraded Petri nets, we extend the Petri nets structure with additional concepts. That means:
    - a Transition Function (TF) is attached to each transition. TF is performed when a transition is fired, e.g. ADD, OR, SUB, EQ (equal), etc. The Transition Firing Level (TFL) is connected with the assigned TF. Timing function is also attached to a transition – the probability that a certain transition will be fired in a certain period of time.
    - each place has two attributes: X – a real number attribute that defines a place state (that can be treated as a register state), and Y – an integer number attribute that is related to the order in which a place will be analyzed when a transition is fired.
    - arc type – normal, inhibitor.
- *The Petri net graph* - is closely related to the Petri net structure. It can be said that the Petri net graph is a graphical notation for the Petri net structure. Thus, the elements of the Petri net structure and the Petri net graph can be implemented together, or dependent on each other. We use term modeling for creating a structure and a graph of some specific model.
- *Petri net simulation* - means firing (execution) of enabled transitions. A simulation changes current marking of a Petri net, and that causes appropriate changes of the Petri net graph. We wanted to implement two different modes of simulation: through parallel execution of all transitions that can fire with a previous conflict resolution; through single execution of a transition that can fire. Each mode of simulation changes a Petri net structure and interactively maps those changes to the Petri net graph.
- *Petri net analysis tools* - there are many well-known Petri net analysis tools, e.g.: Reachability Tree (Peterson, 1981), Matrix Equations (Reisig, 1985) etc. We have also introduced new analysis tools that are appropriate for teaching purposes: Fireability Tree (Štrbac, 2002) – simplified reachability tree, Firing graph (Gašević et al., 2003) – executes the specified number of the simulation steps, draws firing graph of the simulation states (marking), and annotates the conflict situations. We wanted to enable interactive mapping from the analysis results to the model.
- *Petri net model sharing* – that feature should enable model exchange with different Petri net tools, as well as sharing models on the Web. In that way more software solutions could be used for observing the same model. Currently, the XML-based solutions are most common. Especially important is the PNML, a general proposal of Petri nets universal markup (Weber & Kindler, 2003).

According to the identified parts we have created and organized Petri net classes that constitutes the P3's architecture, shown in Figure 1. The Petri net class organization is shown on the left in Figure 1, whereas the supported formats are on the right side. Elements of the Petri net classes are organized according to the previous analysis.

P3's architecture parts that relate to the model formats are also based on the PNML. The PNML extension (UPNML) has been made for Upgraded Petri net markup. We have extended P3 model sharing capabilities with

XSLTs that transform the P3's output format (i.e. PNML) into formats of Petri net tools we have already mentioned: DaNAMiCS, Renew, and PNK. Details of these sharing features as well as experience with their application in practice are given later in this paper. We have also implemented an XSLT for transforming PNML (as well as UPNML) documents to the SVG – the W3C's standard for 2D vector graphics (Ferraiolo, 2001). In this we made possible creation of Web-based Petri net teaching materials using the P3. Additionally, if we empower this SVG format with annotations (e.g. RDF) and Petri net ontology (Gašević, 2004), we will be able to restore Petri net model semantics for the SVG representation.

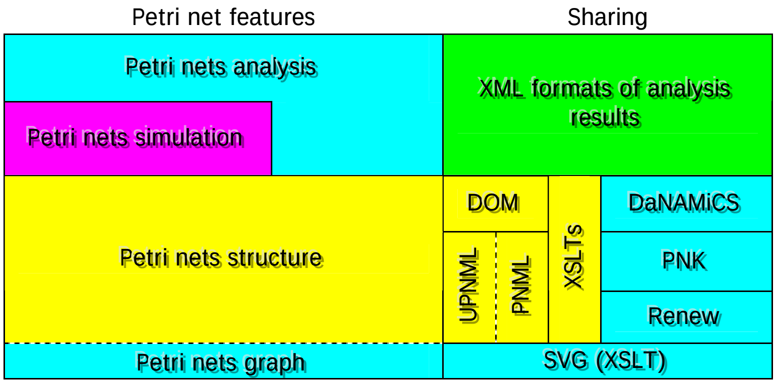


Figure 1. P3 architecture: class organization and supported XML formats

P3 - User Features, and Educational Petri Nt Software

P3 has been developed as a standard Document/View application. It is implemented in C++ using the Microsoft Foundation Classes (MFC) library. The Xerces XML parser version 2.3.0 (http://xml.apache.org/xerces-c/index.html) has been used. XML documents are parsed using the Document Object Model (DOM).

Figure 2 shows an example of P3 screen. The workspace is divided into two parts: on the left side there is a navigation tree of Petri net objects; on the right side, there is a document review of the Petri net graph which is being operated at the moment. Names of all transitions and places of the active Petri net are listed in the left part of the window. Through selection of a particular item in the navigation tree, an appropriate Petri net object will be selected. Features of the selected object, such as name, transition function, place marking, can be changed. This tree has proven to be very useful in practice, since the students got accustomed to the similar user interface organization during their previous software engineering courses (e.g. Rational Rose). It is also possible to write annotations for some objects of the graph shown on the right side of the window. The object selected in the navigation tree can be deleted. In the right part of the window, the graph of the active Petri net is drawn. The modeling function performs in this window. The results of the simulation as well as a single simulation step are also shown.

While places are represented as circles, transitions are in the form of rectangles that become two times wider after a transition is fired – this is useful for learning and better detection of fired transitions. Net nodes are linked by arcs, which were outlined using the Bezier curves. Inhibitor arcs terminate with a circle, whereas arrows at the arc ends mark the direction of ordinary arcs. There is no limit in the number of breaking points. To link two nodes it is necessary to select (using the mouse) a starting node (place or transition), then the arc breaking points and finally, a target node of the Petri net. If a user tries to link nodes of the same type (for example place and place), such linking would be rejected and a dialog would appear giving the information about syntax error that has been made. This P3's feature is useful in the process of learning the Petri net.

Simulation of developed models can be done in two ways:
1. by parallel execution of all transitions that can fire with a previous conflict resolution;
2. by single execution of a transition that can fire.

The first type of simulation is performed in response to a selection of an appropriate menu option (Analyze → Execute Parallel Step), whereas the second one is performed after selecting (using mouse click) a transition that is intended to execute. Both simulation types are performed interactively i.e. their execution changes a marking state of the analyzed net, and the change is automatically reflected on the Petri net graph view in the P3.

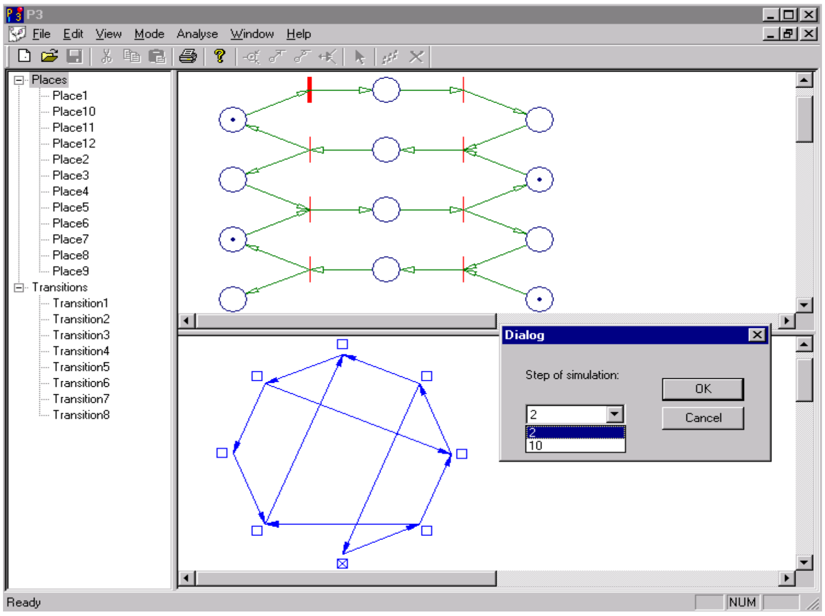


Figure 2. P3's graphical user interface and Firing graph on the example of pipeline model

P3 implements the following model analysis tools: *Firing Graph, Reachability Tree, Fireability Tree*, and *Matrix Equations*. To choose one of those tools, one should use program menu option Analyze->Analyze with, and then select an option with the name of an appropriate analysis tool.

After a calculation with a chosen analysis tool has finished, the right side of the P3 window splits into two horizontal parts. Result of the computation is drawn in the lower part. This layout was made to enable parallel observation of the model and the analysis tool during the learning process. When analysis tools – Reachability tree, Fireability tree, and Firing graph are used, this layout makes possible interaction between a model and the result of an appropriate model analysis method. This paper describes the way P3 presents the Firing graph and performs interaction with the analyzed model. Details of other tools have not been described since the length of this paper is limited.

The Firing Graph has been developed to present the sequence of parallel fireable transitions during the execution of a specified number of simulation steps. In this way one can observe the simulation procedure and conflict situations. Consequently, this tool is convenient for realizing the need of Petri net model analysis, and that is why students should use it in the first phase of learning Petri nets. A set of parallel fireable transitions is marked by □ in the P3 program package and it includes information about simulation step that the system reached in certain state. That information is obtained using a mouse click to select a desired state. A dialog shown in Figure 2 appears, with iteration numbers in which a net in that state is. The initial set of the parallel transitions that can fire is presented by ⊠. If there is a conflict in some state of the parallel transition execution, then that state has a mark □–×. The mark X can be on any side of the rectangle that represents a set of the parallel fired transitions, considering that it is out of the circle which can go round all states the system is during the simulation. The transition to the next state is marked with a directed line. In case transition is performed in one and the same state in the firing graph, such set of the parallel fired transitions is marked with ▢. The presented implementation of this tool enables easier learning of the main algorithm assumptions. An important factor that makes learning easier is interaction between analysis results and the observed model.

P3's XML/XSLT-based Model Sharing

We based P3's format for model sharing on the PNML (Gašević et al., 2003). This P3's format extends the PNML XML Schema definition that is downloaded from (PNML, 2003). We have made the PNML extension in the form of the XML Schema, and for that purposes we used the UML profile for modeling XML Schema (Carlson, 2001). In that way, we obtained the PNML documentation as well as documentation of extensions we have made. Furthermore, this solution is independent of the target XML schema definition language (XML Schema, TREX, RELAX NG, etc.).

We have already mentioned that we have extended the P3 with XSLTs that convert the PNML format into the DaNAMiCS, Renew, and PNK formats. These XSLTs are omitted here due to their length. The transformation principle that was used is illustrated in Figure 3: a P3-generated PNML-based model is the input to the XSLT processor, and it is converted using the XSLT corresponding to the target tool. DaNAMiCS was selected because we wanted to share a PNML-based model developed in P3 with a tool that uses an ordinary text format. Renew was suitable for showing the exchange of P3 models (PNML-based) with a tool that uses another XML-based format, and PNK enabled interchange between two different PNML-based tools. In this paper we give only short overview of our experiences with this model sharing principle, while details can be seen in (Gašević et al., 2003). From the teaching point of view, one can discern the advantages obtained using multiple tools in model observation: DaNAMiCS (analysis tools), Renew (rich graphical environment), and PNK (an infrastructure for Petri net tool development that is convenient for extensions). Of course, there are few constraints of this sharing since none of the analyzed Petri net tools implements Upgraded Petri nets. Recently, we have started to use the PIPE Petri net tool (https://sourceforge.net/projects/petri-net). Our first experience shows that we do not need to perform any additional transformation of P3's PNML models in order to import them in the PIPE tool.

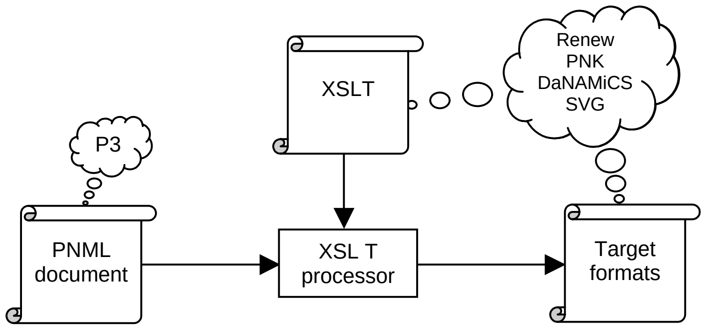


Figure 3. The principle of XSLT-based model conversion from P3 to another format

DaNAMiCS

DaNAMiCS tool is freeware and can be downloaded from http://www.cs.uct.ac.za/Research/DNA/DaNAMiCS/. DaNAMiCS' important advantage is its support for a number of analysis tools, such as matrix invariants and transition matrices, structural analysis, as well as some simple and advanced performance analyses. Due to the fact that DaNAMiCS has more analysis tools than P3, it can improve model analysis for Petri nets developed with P3 when a P3-based model is converted into DaNAMiCS format. Format that DaNAMiCS uses for model import (*File* menu, *Import net* option) is *wam*. Using XSLT, we have converted some P3 models into *wam* format so that they can be imported into DaNAMiCS. However, it is not possible to use XML/XSLT-based approach to convert models developed in DaNAMiCS into some other format, since such models are described as text-based files.

Renew

The Renew tool for Petri nets development can be downloaded from http://www.renew.de. It supports several Petri net dialects: object-oriented Petri nets, high-level Petri nets, P/T nets, and timed Petri nets. Its advantages include: support for synchronization channels, an advanced communication mechanism; support for modeling object-oriented concepts; a number of supported arc types; rich graphical environment (Kummer & Wienberg, 2000). Unlike DaNAMiCS, Renew uses XML to overcome the problem of model exchange with other Petri net tools. XML documents containing Petri net models can be described using a DTD (Kummer et al., 2001). Such DTD is defined starting from the same assumptions that underlie PNML, and as a consequence those DTDs have common elements (net, place, transition and arc). We have developed an XSLT that converts a PNML document into Renew XML format.

Petri Net Kernel (PNK)

PNK is publicly available from http://www.informatik.hu-berlin.de/top/pnk/download.html. PNK is not just another Petri net development tool – it provides infrastructure for building such tools. It is not focused on a specific Petri net dialect; it is possible to use PNK with Petri net dialects with specific extensions (Kindler & Weber, 2001). Publicly available version implements the following Petri net dialects: P/T nets, High-level Petri nets, Timed Petri nets, Bag-based Petri nets, echo nets, and BlackToken nets. PNK also implements graphs, and ghs graphs. The built-in set of dialects and graphs is extensible with new kinds of nets. PNK uses PNML for annotating documents containing Petri net models. It considerably facilitates model sharing between P3 and Petri Net Kernel. However, there are differences in definitions of PNML used in these two tools, hence model sharing between them required building an XSLT as well.

P3 Supported Lessons

In this section we show P3's usability for teaching computer architecture, as well as for model sharing. Firstly, we give an example of a microprogram machine instruction. In order to show how we share P3-developed models with other Petri net tools, we use the well-known synchronization problem – Dining Philosophers (Silberschatz et al., 2003).

The First Microprogram Modeling Lesson: the BIFE Instruction

The control unit implementation techniques (e.g. microprogramming) are a part of AOC course. Here we show the first lesson in using both Petri nets and P3 for microprogram modeling. The example refers to the execution phase of the BIFE (Branch if equal) instruction, which is executed in a simple process model described in (Chu, 1972). Since this model refers to the real system modeling, it is introduced after basic concepts of Petri nets and P3 software, have been covered. The machine instruction compares values of registers A and B, if they are equal, it branches off and increases, in execution phase, the value of the program counter by 8, otherwise it does nothing.

The execution order of micro-operations of this instruction and their representation by Petri nets are described later in the paper. Description order is the same as the one used for their teaching. The model of this microprogram is shown in Figure 4. The X attribute of the Upgraded Petri net represents a state (content) of a component that is used in the microprogram (registers, buses etc.), whereas the Y attribute defines the order of the transition input places (i.e. their X attributes) during function calculation (addition, multiplication). Presentation of the microprogram instruction steps and description of the Petri net elements related to the given microprogram, are given later in the paper.

1. *Transfer of A register's content to the left bus.*

   The register *A* is modeled in the Petri net as a place with the same name (A), whereas the *Lbus* is the left bus. In the Petri net this step represents the execution of the *COPY* transition.

2. *Transfer of the first complement of the B register's accumulator content onto the right bus, parallel adder activation so that the adding is performed with C=1 (we calculate A-B, where B is presented in second complement notation).*

   The register *B* is represented as a place with the same name (B), whereas the place *RBus* models the right bus. The complement of the B register's content is modeled by multiplying (the *MUL* transition) the B's content by -1 (place *Const2*). The adder activation is represented by the execution of the *COPY1* and *COPY2* transitions and token generation into the *P3* and *P4* places, which represent the adder entries. The adder performance is represented by the *ADD* transition, whereas the addition result is in the *SUM* place.

3. *Output of device for zero check (ZT sets) sets flag Z.*

   Checking if the result of the addition (the *SUM* place) equals zero (the *EQ* transition) or not (*NEQ*).

4. *Storing the address into the microprogram address register*

   In case that the register's content is not equal zero, the *NEQ* transition is fired and the token is generated in the *New instruction* place, which means that it is possible to obtain a new instruction for the execution.

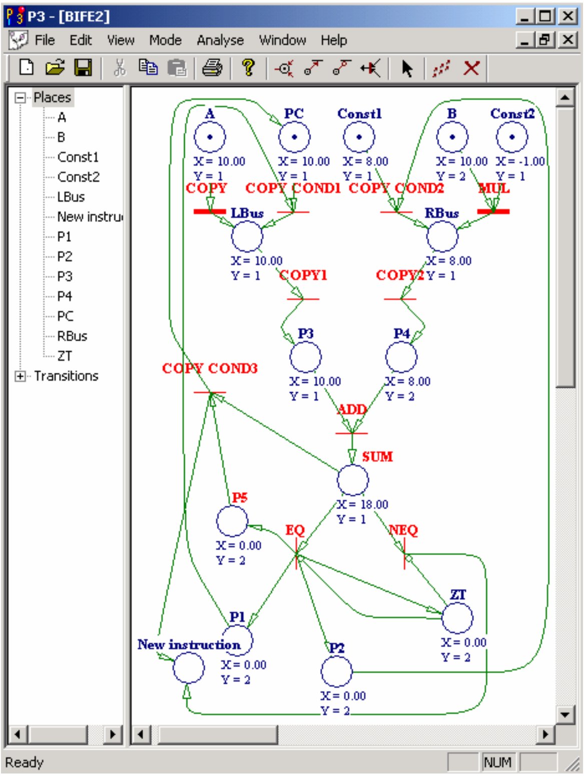


Figure 4. A microprogramming lesson: the BIFE instruction

5. *If condition A=B is fulfilled the content of the PC is put on the left bus*

   This step fits the execution of the EQ transition (SUM was 0), and after execution is done, tokens are generated into P1, P2, and P5 places. The P2 place serves to signal firing of the COPY COND1 transition because the place that models the PC already has a token. The PC content is copied on the left bus (LBus) through execution of the COPY COND1. A token in the P5 place should enable copying of computed result into the PC (a new value).

6. *Setting the constant (c=8) on the right bus.*

   The constant 8 is represented as the Const1 place. This step is modeled as execution of the COPY COND2 transition and copying of the Const1 content into the RBus (the right bus). The token has previously been generated into the P2 through execution of the EQ transition and the COPY COND2 becomes fireable.

7. *Parallel adder activation (adding PC + 8).*

   The adder activation is represented as execution of COPY1 and COPY2 transitions and bringing left and right bus content (LBus and RBus places) to the adder entries (P3 and P4). Adding is represented as execution of the ADD transition followed by placing the result in the SUM place in which this token is also generated.

8. *Result transfer from the main bus into the PC.*

   This operation is modeled as execution of the COPY COND3 transition and copying SUM content into the PC. The token is also generated into the New instruction place, which is a signal for obtaining a new instruction.

Pedagogically, this example is suitable for illustrating the use of the Firing graph, as well as for understanding approach to its simulation-based calculation. Namely, in the first iteration of the Petri net shown in Figure 4, there is not any output arc from the EQ transition to the ZT place. According to this, when the content of A and B registers are equal, the PC content is increased by 8 (transition ADD). Consequently, there is a conflict in the SUM place (a token for the NEQ and COPY COND3 transitions, where the NEQ should not be fired again). This simulation flow is illustrated by the Firing graph from Figure 5a, which has one conflict state. If there is the arc between the EQ and ZT, then the conflict is eliminated (Figure 5b).

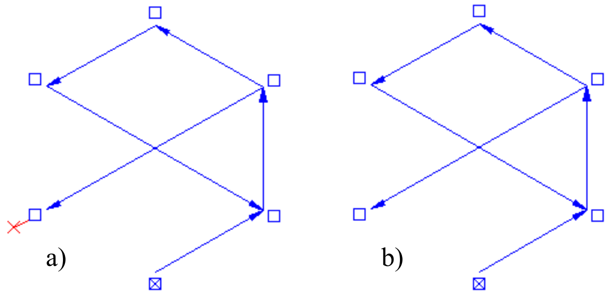


Figure 5. Studying the Firing graph: a) with conflict, b) without conflict

P3 Interoperability

Distributed and multiprocessing computer architectures are an advanced part of the AOC course. In this course part students can see full Petri net potentials for system modeling since Petri nets have different analysis tools, for example, that can detect deadlocks. In the AOC course, we firstly, introduce distributed hardware concepts and synchronization mechanisms using the examples of well-known problems (e.g. Dining philosophers, Producer/Consumer, etc) (Peterson, 1981; Murata, 1989; Silberschatz et al., 2003). Then, we show how these concepts can be analyzed using both Petri nets and P3. At this point, we mention students that P3 has a limited number of analysis tools. For instance, the P3 does not support the following analysis: boundedness, liveness, T- and P- invariants, different time analysis, coverability graph (Murata, 1989), etc. However, these can be done using DaNAMiCS tool. Hence, we emphasize P3's model interoperability. In Figure 6 we show the Dining philosophers Petri net modeled in P3. Also, this Figure shows reachability tree of this model that can be used for detecting deadlocks. Students can use P3's reachability tree not only to analyze a model, but also to understand this analysis tool since P3 provides result mapping from a tree (i.e. its nodes) to a Petri net.

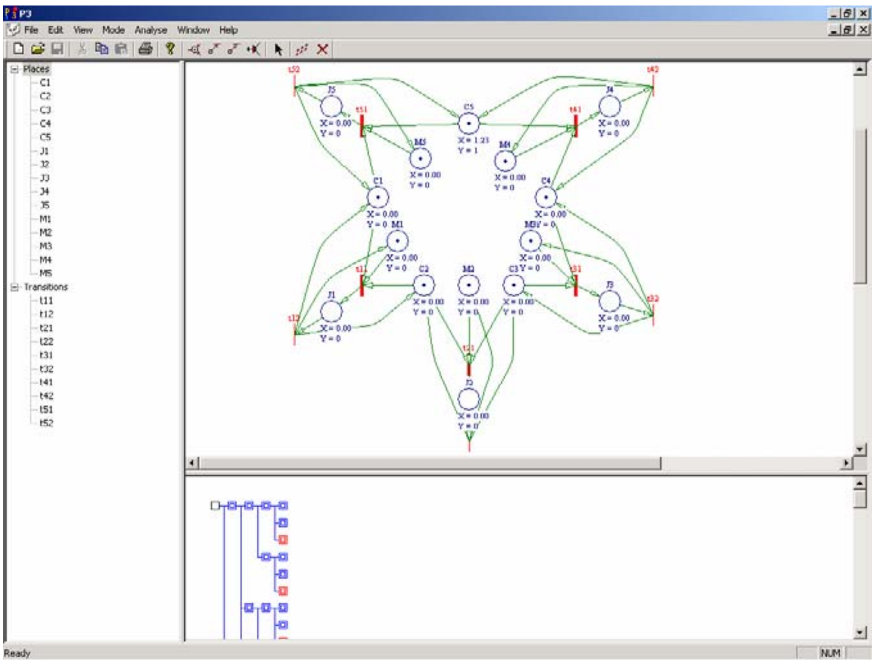
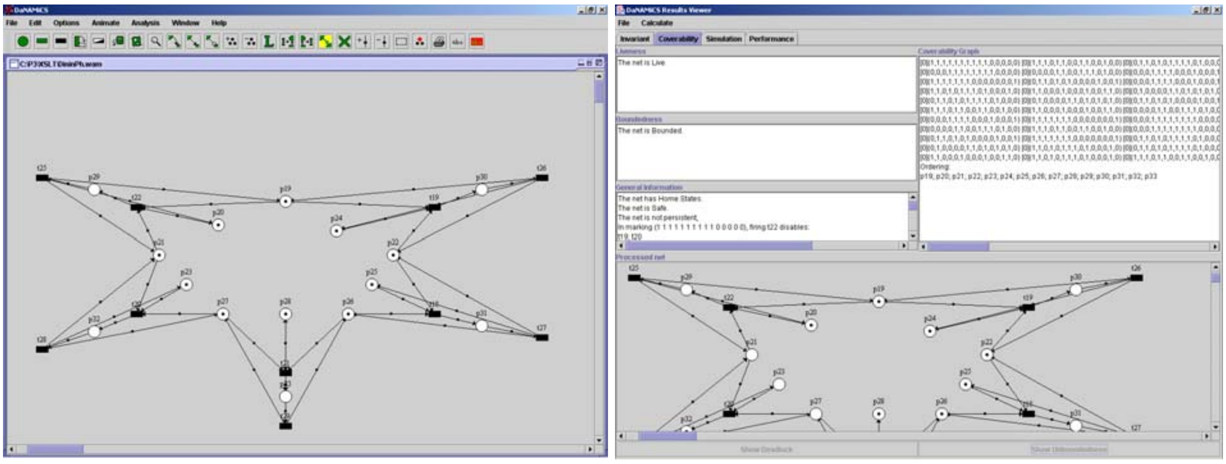


Figure 6. Modeling distributed systems using P3: problem of Dining philosophers

In Figure 7a we show the same Petri net model of Dining philosophers that we have exported from P3, and imported in DaNAMiCS. Figure 7b depicts a part of DaNAMiCS' analysis capabilities: liveness, boundedness, coverability graph, as well as annotation of deadlock and unboundedness. Of course, we should note that Petri net models, which P3 shares with DaNAMiCS, can not be created in Upgraded Petri nets since DaNAMiCS does not support this Petri net dialect. There are similar limitations for model sharing regarding the Upgraded Petri nets between the P3 and Renew, PNK, and PIPE.



a) b)

Figure7. P3 and DaNAMiCS model interchange: a) exchanged model of the Dining philosophers from Figure 6; b) a part of DaNAMiCS' analysis results of the exchanged model

Analysis and Evaluation

An important, both practical and research topic in the area of Intelligent Educational Systems (IES) is that of evaluation strategies and performance measures (numeric) that could help quantify and rank a given learning environment and assess how different learning environments compare to each other (Devedžić, 2003). Note that evaluation is concerned with IES performance and its decision-making capabilities, as opposed to assessment, which is about the effectiveness of the system based on measuring learners' outcomes (Gilbert et al., 2001). Evaluating IES is difficult because the underlying theories are either new or still under development, and there is no widespread agreement on how the fundamental tasks (student modeling, adaptive pedagogical decision making, generation of instructional dialogues etc.) should be performed (Mitrović et al., 2002).

Although P3 tool is not classical educational systems (i.e. IES) it can be considered as a part of learning equipment. In this paper we analyze P3 in order to show: P3's impact on students' outcomes at the end of the AOC course, students' subjective evaluation of the P3 tool, and teachers' (i.e. ours) subjective observation of P3's benefits to the course realization. It is important to note that each year we have only one group of students in summer semester. In this paper we show results we got in realization of the AOC course last year (2003). The group consisted of 55 students. We have compared this group's results with results of the group that attended the AOC course a year before (2002). That group consisted of 50 students.

Students' Outcomes

We tested our students after each lecture in the AOC course. These tests were not performed on computer, but in the written form. In the figure 8 we give comparative overview of students' results when they did not use P3 during lectures, with the results obtained when students did use P3. One can see that the average student score is higher with P3 (77.27% average score of 55 students – these results are for the course in 2003) than without it (75.19% average score of 50 students – results from 2002). It is interesting to note that main improvements were in the following lectures: 7 (Multiprocessor systems), 8 (Vector and matrix processors), and 9 (Elements of distributed systems). Such results were expected since the main purpose of Petri nets is to model and simulate distributed and parallel systems and processes. In some other lectures (e.g. lectures 3 and 4) one can note lower score with P3. We should point out that in these two tests our main focus was not measuring Petri net skills. In this moment, we are not yet able to draw any general conclusion about P3's influence on the AOC course. In order to make a more general claim we should observe students' results in a longer time period (e.g. five years).

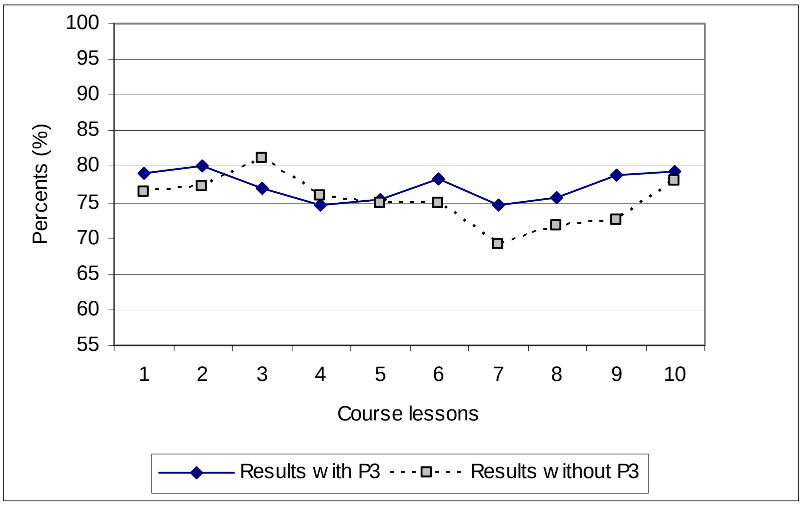
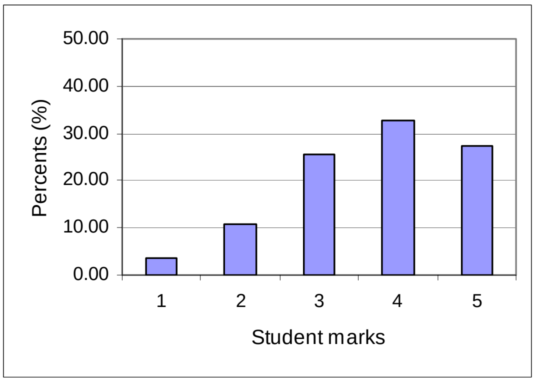


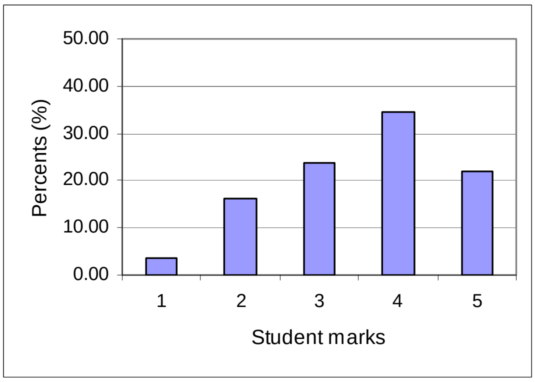
Figure 8. Comparative overview of student assessment in the AOC course: student results without P3 (First year) and results with P3 (Second year)

Students' Subjective Evaluation

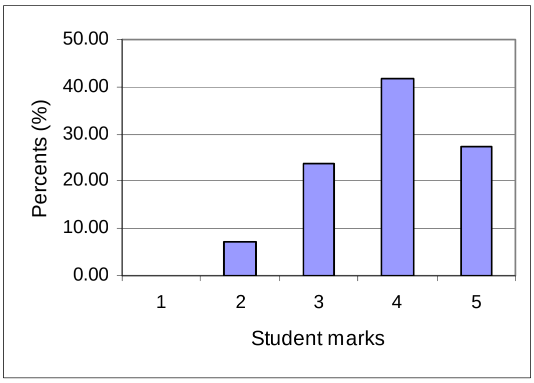
Here we present a summary of the students' answers to the user questionnaire. The students filled out a questionnaire at the end of the AOC course in which they used P3. The purpose of this questionnaire was to evaluate students' perception of the P3. The questionnaire consisted of 10 questions, each one based on the Likert scale with five responses ranging from very much (5) to not at all (1). Additionally, at the end of the questionnaire we provided a place for free form students' comments. We based our approach to evaluation of students' perception of the P3, on experiences shown in (Mitrović et al., 2002).



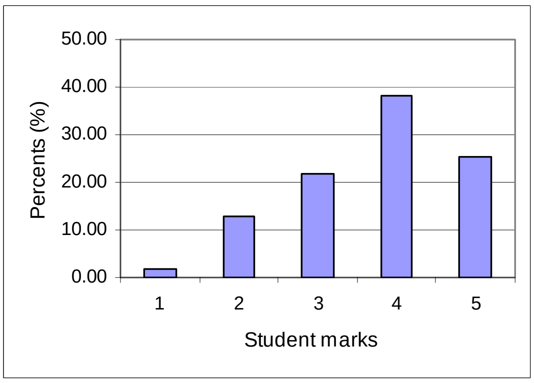
a) Do you find the interface easy to use?



b) Do you think P3's analysis tools useful?



c) How do you mark P3's interchange facilities?



d) Did you find P3 tool useful for understanding Petri net concepts?

Figure 9. Students' responses from the questionnaire at the end of the course (1 – Not at all, 5 – Very much)

In Figure 9 we give students' answers to some questions. We believe that shown answers can depict students' perceptions of P3's features in regard to our starting goals. It should be noted that P3's model sharing facilities (Figure 9c) are best marked. Actually, majority of students' comments regarding this feature suggested that it would be useful to empower a future P3 version with bi-directional interchange ability (e.g. P3 should have capabilities to import models from DaNAMiCS and Renew). Students remarked that the main P3's drawback is absence of structuring mechanisms since all real-world systems use Petri net concepts. Furthermore, they gave lower marks for P3's user interface (Figure 9a). All students had consistent agreement that P3's analysis tools (Figure 9b) and P3 tool itself (Figure 9d) are useful for understanding Petri net concepts.

Teachers' Subjective Analysis

We have noticed the following advantages P3 supported learning process:

- Students learn Petri nets' syntax while using this software, since P3 does not allow breaking of the syntax rules. This refers to the situation of connecting nodes to networks. For example, P3 does not allow a connection between two transitions. P3' dialogs that notify user about inaccuracies that caused an error, have proved to be especially useful.
- Execution rules of Petri nets can be learned through interactive execution of simulation. Students can understand simulation of simple models without problems. However, with complex models, ability to use a software that interactively changes the state of the Petri nets graph (marking) after the execution of the simulation steps, proved useful.
- Implemented analysis tools make basic ideas of their algorithms easier to understand. This is possible to accomplish by copying the results onto the analyzed model. We have already illustrated this process with an example of the Firing graph. The Reachability Tree and the Firing Tree are used in a similar way.
- A need for system modeling, precise definitions of design requirements and their adequate software support are obvious.
- Students understand advantages of using both simulation and software simulation tools, with the aim to cut the costs of hardware systems' development and increase system development productivity through exploitation of software modeling support. In this way students understand the need for software support for complex systems modeling, since without such support it would be difficult to perform required model analysis.
- P3 software makes verification of ideas possible even without physical implementation. The use of the P3 for these purposes, as well as its use for the detection of conflicts in the model are shown in the Firing graph in Figure 5.
- Students understand importance of model sharing for Petri net supported development. With model sharing facilities, we are not limited to use only one Petri net tool. Additionally, students learn importance of model interchange standards and advantages of having XML-based formats like PNML is.
- Since our students are pursuing to obtain degree in computer engineering, they have good skills in software engineering and Web technologies. Accordingly, they realize techniques for extending current Petri net tools with modules for model transformation (e.g. XSLT when we use XML).

Beside these advantages that have been noticed while using P3 in practice, the authors believe that it would make a significant advancement if we:

- Implement support for structuring mechanisms, such as pages and references to the nodes of Petri nets, as well as modules and instances.
- Make component libraries that would model most often used hardware mechanisms such as memory decoders, memory, arithmetical-logic units, DMA, etc. It would be a good illustration of current hardware engineering modeling.
- Implement tools for dynamic model analysis, beside structured tools that are already implemented in the current version of the P3.
- Implement complex tools for model analysis, such as deadlock detection, which would enable students to understand the importance of analysis tools.
- Provide support for Petri net Web-based educational infrastructure in terms of development of both the Petri net ontology (Gašević & Devedžić, 2004) and Petri net Web Service (Havram et al., 2003). In that way we would obtain better Petri net learning features using recent Web-based educational system proposals (Devedžić, 2003) (e.g. create Petri net learning system that will use RDF-annotated Petri net SVG representation in accordance with the Petri net ontology).

Conclusion

Development of P3 software support for studying Petri nets was motivated by the need to teach parts of the Architecture and Organization of Computers course and to employ Petri nets for hardware modeling. In order to give educational character to the P3 software, we have: developed graphical user interface that supports discovering syntax errors in Petri nets and informs users about them; introduced interactive simulation and model analysis; provided possibility for the model exchange with other Petri nets software tools based on PNML. The abbreviated version of the P3, its technical description, as well as developed XSLTs can be downloaded from http://www15.brinkster.com/p3net. Our first experiences in using the P3 tool are quite positive. Especially, evident improvements have been mentioned in the topics that consider parallel and distributed systems (multiprocessors, matrix processors, etc.). From the students' questionnaire we obtained some very useful suggestions for future P3's versions.

We hope that our experiences could be useful for those who teach and use Petri nets in different computer science courses. Especially, we think that P3's interoperability demonstrates valuable improvements of current Petri net software support for teaching. Also, we believe that P3 can be useful for other courses such as Expert Systems, Computer Networks and Communications, and Programming Languages.

Our on-going effort is to develop a Petri net Web-based educational system. This system should consist of a Petri net ontology and a Petri net Web service. Currently, we are extending P3 with support for RDF, as well as for RDF-based annotation of SVG Petri net models. We will use annotated SVG documents in collaboration with the Petri net Web Service. Furthermore, we will use this annotation principle to develop a Petri net Web-based learning environment as well as to make a relation between Petri net models and Learning Object Metadata (LOM) repositories.

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Evaluating the Cost Effectiveness of Online and Face-to-Face Instruction

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Abstract

Online instruction is gaining an increasing presence due to the benefits associated with it, including the ability to consolidate education and training across geographical and time constraints, and the claim by many that online education and training is cost efficient. This paper provides a relatively concise and useful history of online learning, and a discussion of issues to be faced by the professional who intends to move the education and training environment online in response to the current academic and business environments. It presents a cost matrix tool by which the costs of online education and training can be tabulated and/or compared with the costs of the traditional education and training medium.

Keywords

Online education, Online training, Face-to-face training, Cost matrix

Introduction

The advent of the Internet and the widespread adoption of advanced technological measures have led to a new emphasis on online education and training both in the academic and business worlds by providing unique alternatives for reaching larger audiences than ever before possible. In the academic world, universities now have the ability to provide distance learning opportunities through online classes for students—traditional or non-traditional, full-time or part-time, and international—who perhaps have had limited access to advanced educational opportunities. Online education is especially valuable to those students who juggle demanding work, familial and social schedules that necessitate access to learning in special forms. The idea of online training becomes valuable to the business world as well as trainers also face situations with adult learners who may experience similar constraints especially those of time and geographical distance.

Statement of Problem

The current academic and business environments in the global economy view the implementation of online education and training programs as a necessary avenue for training and implementing programs across the global network. However, the rapid adoption of online education and training has created a void in the literature. Those few studies published to date primarily compare online education to tradition education rather than evaluating the ability of an online education course to meet its predetermined goals (Newton et al., 2002). A study completed by Aragon et al. (2002) evaluated learning in the online and "traditional" classroom, and found no significant differences between the methodologies. Given the lack of conclusive research concerning the effectiveness of online education, cost comparison factors may serve as the primary criterion to determine which methodology to use. The question to the academician and to the business professional however becomes how to determine the cost effectiveness of education programs offered online when compared piecewise to the traditional education medium. The cost matrix proposed in this paper provides the professional with a tool to compare the costs of educational programs offered online to that of programs offered face-to-face in a more traditional educational setting.

Theoretical Framework

History of Distance Learning

Using distance learning to further educational goals is not a new concept. Late in the nineteenth century, the American public became involved with correspondence education through the postal system. Distance learning eventually evolved with technology through the introduction of radio programming, then local television such as PBS, and eventually to telephone- and video-based courses. In recent years, the availability of Internet access and widespread adoption of affordable personal computers has made online education the largest sector of distance learning (Evans & Haase, 2001). In the early nineteen-nineties, online education was limited to a small number of expensive electronic classrooms owned and operated by large universities and businesses, but today the technology is pervasive and available to large sections of the public (Kilby, 2001).

The advent of the Internet has had a profound effect on business, forcing the evolution of everything from ordering systems to selling platforms. A similar impact is expected for distance learning. E-businesses are discovering that e-learning has great growth potential, and that this directly equates to increased profits (Kilby, 2001). These impending changes require a reconceptualization of how training courses are designed (Lairson, 1999). The evolution of training had begun, but much still needs to be considered as attitudes and technologies continue to change. These developments are further necessitated as the clientele for training changes. An increased emphasis on globalization, development of increasingly sophisticated communication systems, the need for lifelong learning, and the growth of the earner-learner environment drives these changes. In fact, Price Waterhouse Coopers estimates that approximately seventy percent of large companies cite the lack of trained employees as a major barrier for future growth (Clarke & Hermens, 2001).

The technological infrastructure necessary for online learning is firmly established through recent rapid improvements in bandwidth, the pervasiveness of computers in the household, improved technological standards, the permeation of computers into schools and businesses, and the adaptive nature of technology (Clarke & Hermens, 2001). The majority of moderate and large sized corporations and universities have extensive information technology groups to manage and develop their systems; therefore, adequate resources should exist to form project development groups for extended online training systems. However, if businesses and universities and their training and development professionals fail to recognize the large potential commitment of time and resources to the development, updating and maintenance of these systems, a significant financial and resource drain could be placed on the organization.

Business trainers and academicians deal primarily with adults who come with many familial and social commitments, and who need the ability to learn without geographic boundaries. Further, these older learners are different from the traditional student in that they are continuous, informal, adaptive, and motivated learners who seek the ability to stay competitive in their lives and also for career advancement (Evans & Haase, 2001).

Models of Online Learning

The face-to-face classroom environment has many established models for optimizing the learning process, but online education currently lacks models upon which to structure its processes. Typically, a common misconception in the application of existing pedagogies occurs when traditional classroom models are merely adapted into the online medium (Shaw, 2001). The main barriers associated with the online learning environment lie not with the technologies currently available, but with the pedagogical assumptions and conceptions underlying their use. The development of innovative and effective methods made possible by advanced technologies are constricted by the narrow perspective of online education held by many who think only of static online tutorials and online books (Kilby, 2001). This greatly hampers the development of innovative and effective methods for completing educational processes online. Given the wide availability of technology in the marketplace, both at learners' residences and workplaces, the options are innumerable. Many practitioners fail to reframe their conceptions of learning and teaching in the online environment, leading to extremely damaging consequences for the learners involved in the training. Another problem is the common juxtaposition of pedagogy and technology. Although the natural tendency is to separate them, the practitioner should consider simultaneously pedagogy and technology as s/he designs and develops the online learning experience (Jackson & Anagnostopoulou, 2001).

Online learning is a subset of a collection of learning tools collectively referred to as flexible learning. To date two primary pedagogies have been associated with these learning environments: student-centered learning and experiential learning. Student-centered involves negotiation between the learner and the instructor as to how learning proceeds in the “classroom.” Experiential learning allows the learner to exhibit a degree of control over the situation and determines the degree by which he or she becomes involved. Further, experiential learning has a degree of correspondence between the learning environment and the real environment where daily work is conducted (Thorpe, 2000) and can be successfully used for teaching cognitive concepts as well as preparing learners in academic and work settings to develop conceptual, judgmental and cognitive skills so important in today’s workplace (Bartley, Kupritz & Powers, 2003).

The ILDIC model (Integration Learning Design in Multimedia CD-ROM) identifies many required components of e-pedagogy and suggests that the e-learning pedagogue needs to include conventional pedagogy, online awareness, the ability to plan and manage events online, comprehension of the current and future potential of technology, and the ability to interweave technology into the training design (Good, 2001). Taylor (2002) asserts that the following ideas also need to be considered in the implementation of online programs: using online learning efficiently, team-based efforts, additions to existing classroom presentations, both synchronous and asynchronous programs, the trainer learning curve, cost, using multimedia to augment presentations, reaching distance learners, assessing learner needs, ability to access course material, ability to distribute course information, ability to give and receive feedback, class management techniques, techniques to measure results, and procedures to update material. In order to successfully meet these requirements, one needs to devise an infrastructure to support distance-learning needs and to orient distance-learning programs to traditional programs (Evans & Haase, 2001).

Wild et al. (2002) discusses the development of an e-learning value chain within organizations which includes the following steps: assessing and preparing organizational readiness; designing appropriate content; designing appropriate presentations; implementing e-learning. Reducing the training process to a logical value chain provides additional methodologies that may help in the justification of training programs. Presentation of a well thought out and documented plan is far more likely to gain support than less structured ideas. Further, these steps combined with one of the currently accepted models can constitute a comprehensive and effective e-learning program. The currently accepted models include CBT on the Web (popular for occupational training), synchronous learning and the electronic classroom (Whitlock, 2001).

Bates (1995) discusses the ACTIONS model for assessing learning technologies such as online learning. The ACTIONS model includes consideration of the access, costs, teaching and learning, interaction and user-friendliness, organization, novelty and speed of the training intervention being developed. Each of these issues is imperative to consider in the development of new training models, especially when one is considering the use of new training methodologies that have not yet been fully validated, such as online training.

Benefits of Online Learning

The many benefits associated with online learning are well discussed in the literature. First and foremost is the current economic situation, which necessitates the need for companies to economize. With more than fifty million workers to re-train, any discovery leading to decreased expenses is extremely well received, and distance-training programs have already proved their ability to save millions of dollars each year (Evan & Haase, 2001). In today’s rapidly changing work environment, the need for just-in-time training, similar to the many other just-in-time functions such as production, is essential (Wild, 2002). Economic and time benefits achieved from training are essential in the current environment; therefore the creation strategic alliances for the training function have become extremely popular. Businesses and educational institutions have begun to join together to share in the responsibility of building a globally competitive work force (Vincent & Ross, 2001). Firms seek to position themselves to be the most competitive in the new international marketplace, and e-learning is a way to empower such a workforce with the skills and knowledge necessary to create those advantages (Wild, 2002). In order to actually achieve these goals, companies must revise their perception of training as an unredeemable cost to the company and view expenditures to develop human potential as an investment with unlimited potential returns (Vincent & Ross, 2001).

The returns of training, whether traditional or online, include improved performance and attitudes from employees necessary to achieve organizational growth (Kilby, 2001). Online training allows learners to work at their own pace to complete required technical and work related training or complete full degree or certification programs (Taylor, 2002). Online training and education allows learners who would be otherwise denied the opportunity to increase their personal knowledge and abilities, the ability to reach the tools to empower themselves (Furnell, 1998). Further, the use of online and distance training has removed the need to travel in order to join together to learn and study (Cornford & Pollock, 2003). This results in both significant cost reduction and also reduction in lost time and opportunity from having employees away from their responsibilities for extended periods of time.

Evans & Haase (2001) discuss ten benefits of online training that are readily available to companies upon the implementation of these new and innovative programs. These benefits include increases in the impact of the money invested in training programs, significantly reduced employee travel cost and time, the ability to train more people, more frequently and in shorter sessions that are easier to coordinate and schedule. Further, online training is scaleable because it offers the ability to add instructors and students as needed, with fewer changes and re-developments. Trainers now have the ability to deliver programs with a consistent message in a way that can quickly be disseminated company wide, with real-time updates and information access. With online training, the concepts for group learning and collaborative problem solving can be delivered to networked sites, including the employee's home.

Online training is learner-centered, which allows learners more control with course pacing, sequencing and styles. The benefits of online training can be achieved through the development of corporate universities or through the use of strategic alliances between technology and media companies, learning and research universities and newly formed and developed e-learning companies (Clarke & Hermens, 2001).

Bartolic-Zlomislic & Bates (1999) identify many potential benefits associated with online learning. First and foremost is the ability to reach new markets, both national and international. Given the widespread competition for the best courses in the academic world and the multinational nature of many corporations, this is a more important benefit than ever before. Along with the ability to enter new markets comes the ability to form international partnerships for online learning. Economic benefits associated with online learning include the fact that many times online learning can fully recover its costs within only a few training sessions. However, this is not always true and requires a complete and comprehensive evaluation of the costs associated with a given online learning program. In addition, online learning can also result in a reduced time to market for courses. This benefit is dependent on the skills of the designers and their familiarity with the online format. Educationally we see benefits for the students not only through their learning of the course material, but also through their learning of new technologies.

Limitations of Online Learning

The integration of online training can have a large impact on the learning and performance of the employees involved in the company processes. Although online learning is becoming mainstream in many organizations, many doubt that it is adequately meeting the needs of either the learner or the organization (Kilby, 2001). There is a continued idea that the online training outputs should only be compared to those that have been achieved previously by the "traditional" training functions. The focus should be shifted to include the evaluation of whether or not online training is meeting the goals that were set out during the planning stage of the training (Jackson & Anagnostopoulou, 2001).

Without the evaluation of learning and performance achieved by these programs, one faces the very real possibility that the company will cease to place support in favor of training programs (Jakupec, 2000). Further difficulties encountered in the use of online training programs are faced in the evaluation stage of the program. To date, there has been the inclusion of some assessment, but few formal training evaluation processes have been implemented (Kilby, 2001). In order to justify the results of the training programs, better tools are needed to evaluate the results of training.

Little discussion can be found in the literature about the financial constraints of the online training medium. Although Swanson (2001) proposed how to show the cost and benefit of a training program, others have focused little attention on the comparison of costs between different program options. Phillips (1997) proposed that costing methods should determine "fully loaded costs" – all costs identified and linked to design, development and implementation of a specific program. A case study presented by Philips (1997) provided a cost matrix for a fully loaded program, but again the tool stopped short of comparison between different programs.

Some fear that too much emphasis is placed on the technology of online courses, often at the expense of the learning and design process. The experience that a learner has in the online classroom is determined largely by the way new learning technologies are presented. The technology must be able to deal with a multitude of learning theories and learning styles (Whitlock, 2001). Vincent & Ross (2001) discuss the directed use of learning styles in the online classroom. They suggest allowing the learners to determine their learning styles individually using many readily available online tools. The results of these exercises can be presented to the facilitator or instructional designer, and used to assist in assessing and meeting the unique needs of the adult learner. Vincent & Ross (2001) present a variety of Internet sites where tools for evaluating learning styles, personality types and multiple intelligences are freely available.

Design Issues Concerning Online Learning

Although instructional design has always been an important aspect of education and training, the implementation of online learning programs necessitates the need for particular attention to be paid to the design process. A more global view of design must be adopted if online training is to achieve its potential to be adaptable to a multitude of learning environments (multi-national, multi-lingual and international collaborations), reduce travel time, and reduce overall cost to the learning organization (Kilby, 2001). Design methods ensure that a variety of resources and activities are included in the course and that the amount of technology used is not overwhelming to the student (Shaw, 2001). An equitable match should exist between the materials and medium being used in the online training environment, and assurances made that all of the technology is readily available to the learners (Evans & Haase, 2001). Instructional designers must have a concrete understanding of the theory behind their learning models in order to be effective in the online environment (Good, 2001). In the development of online courses the majority of the focus seems to be given to the concrete aspect of the course, with little thought given to the complete integration of e-mail, discussion groups and chat functions. Without the complete integration of such functions, the learner in the online environment can become lost in the virtual world, without recourse in times of need (Kilby, 2001).

Companies reaching the time where employee skills require constant updating to meet changing demands may rush to implement online training courses without the required degree of planning and research jeopardizing the many benefits associated with adequately planned online training (Newton et al., 2002). A dull, unrewarding course taught in the classroom environment becomes even duller and less rewarding in the online environment (Kilby, 2001). Just like in the “traditional” training environment, the users of online learning seek a satisfying learning experience and the perception that they have gained knowledge and skills. By its nature, online training occurs without extensive interaction between members of the class and the trainer, which can lead to an anti-social environment where learners feel isolated (Kilby, 2001). Swanson & Holton III (2001) discuss the importance of social learning as part of the learning process in learning organizations. The new online courses must be developed from a learner-centered model, with instruction that begins at the learner’s level of current understanding with his/her needs driving the training process.

In order to design effective online courses, education and training professionals must negotiate the social, economic and political policies that govern and influence the training procedures in place at the university or corporate levels. The education and training professionals must effectively and efficiently provide appropriate learning materials to the learners as well as provide for practice for realistic work situations (simulations, for example). A usable mechanism to answer questions and foster discussions among learners must be available as well as an assessment tool(s) to assess learning both effectively and accurately. Facilitators and learners must have the ability to access quick and accurate technical support services. Many of these design and learning considerations can be achieved through the use of simple chat and e-mail functions that are readily available with appropriate technology. As an example, even with very limited programming skills, a practitioner can create interactive applets that reside on the Internet or on one’s personal computer to facilitate the learning of new ideas. However these innovation elements must be incorporated during the design phase, not added as an afterthought.

Another new aspect of instructional design to be implemented is the aspect of online security. To date, significant consideration has not been given to the use of security features for adequate securing of private information. Furnell et al. (1998) discuss the security framework that should be considered in the development of these new courses. They consider the online course as a five-stage model: enrollment, study, suspension, completion, and termination. Each of these stages has its own idiosyncrasies and poses potential problems that need to be clearly evaluated prior to the distribution of online modules for many reasons, but primarily for the protection of proprietary information. The issue of security in the online environment must remain a primary concern of the education or training professional as the necessary learning materials are developed and distributed.

Costs of Online Learning

Models for Determining the Costs of Online Learning

Determining the cost of online learning is an essential component in deciding whether these new techniques are appropriate for a particular organization. In addition to examining the value added components for learning, one must also consider the cost, and whether these costs are justifiable.

Bartolic-Zlomislic & Bates (1999) discuss the potential benefits and limitations of online learning, including careful consideration of the costs associated with online learning. They suggest dividing the cost factors into three groups: capital and recurrent costs, production and delivery costs and fixed and variable costs. Capital and recurrent costs include things such as equipment and support for the equipment, production and delivery include those costs incurred in the development and delivery of the course, and fixed and variable costs are those that either remain constant regardless of the number of participants (fixed) or change with the number of participants (variable).

Calculating the ROI of Online Learning

The calculation of ROI as a justification for a training intervention is a more important facet of the training proposal than ever before. Without a comprehensive evaluation of the costs and saving achieved though implementation of the training program organizational leaders will have a hard time approving the necessary funds for development of the training intervention.

The ROI calculation has been presented in the training literature in a number of sources. Simply, the ROI calculation requires only knowledge of the net program benefits and the program costs. A ratio of these two numbers indicates the return on investment. One of the reasons that trainers often fear making this ROI calculation is fear that the net program benefits cannot be accurately predicted. Computation of the program costs, while cumbersome, can easily be accomplished with a modest time commitment. Computation of the net program benefits requires some complex assumptions concerning the effectiveness of a program that has yet to be designed or implemented.

Evaluating the Costs of Online versus Face-to-Face Learning

The current business environment has led to many changes in the allocation of funds within an organization. Today it is much more difficult to justify the expenditures on any number of different items. People look at training and see a quick fix through the use of online training tools. What they fail to evaluate is whether or not online learning is really more cost effective than face-to-face learning. In most situations it will be true that given staff who have experience in the technical aspects of developing online training and enough time, online training will become more cost effective than face-to-face training. The large initial expenditures in new equipment and training for the developers can take a substantial amount of time to implement effectively. Bartolic-Zlomislic & Bates (1999) discuss that the start up costs associated with an online learning program can often be cost prohibitive for many organizations.

Consideration of the cost of online learning is not a new concept. Bartolic-Zlomislic & Bates (1999) discuss these costs in their article and many others have stimulated similar discussions. Turoff (1997) discusses the costs for the development of an online university under a set of assumptions. These assumptions include the fact that students with work in learning groups or teams, there will be a group orientated communication system, faculty already know the necessary technology, technology will be used for all the tasks and the internet is used as the primary form of delivery. Although these assumptions may be realistic for some organizations, for many they will be highly unrealistic. In many organizations the assumption that faculty or trainers are already familiar with the necessary technology is a highly unrealistic assumption. Others make similar gestures for the discussion of the costs associated with online learning.

		Online Training		Face to Face Training	
		One Time Costs	Per Session Costs	One Time Costs	Per Session Costs
Analysis					
	Analysis Team Costs[1]				
	Office Supplies and Expenses				
	Printing and Reproduction				
	Outside Services				
	Equipment				
	General Overhead Allocation				
	Miscellaneous				
	Total	$ a		$ a	
Design / Development					
	Design and Development Team[1]				
	Design User Interfaces				
	Asynchrous Computer Systems				
	Synchrous Computer Systems				
	Design Function Elements				
	Asynchrous Computer Systems				
	Synchrous Computer Systems				
	Design Graphical Resources				
	Asynchrous Computer Systems				
	Synchrous Computer Systems				
	Office Supplies and Expenses				
	Program Materials and Supplies (i.e. Film, Videotape, Audiotape, overhead transparencies, artwork, manuals and materials, and miscellaneous)				
	Printing and Reproduction				
	Outside Services				
	Equipment				
	General Overhead Allocation				
	Computer Resources				
	Individual Computer Costs / Upgrades				
	Computer Classroom				
	Server Purchase / Upgrade				
	IT Salary Support[1]				
	Miscellaneous				
	Total	$ c	$ d	$ c	$ d
Implementation					
	Participant Costs [1]				
	Instructor Costs[1]				
	Program Materials and Supplies				
	Participant Replacement Costs				
	Lost Production				
	Facility Costs				
	Facilities Rental				
	Facilities Expense Allocation				
	Catering				
	Equipment				
	General Overhead Allocation				
	Miscellaneous				
	Total		$ g		$ g
Evaluation					
	Evaluation Team[1]				
	Participant Costs[1]				
	Office Supplies and Expense				
	Printing and Reproduction				
	Outside Services				
	Equipment				
	General Overhead Allocation				
	Miscellaneous				
	Total		$ i		$ i
Grand Total					
	Fixed Costs for Training Session (a+c)	$ f		$ f	
	Per Training Session Costs (d+g+i)		$ e		$ e
	Anticipated Number of Training Sessions		b		b
	Total Overall Costs for all Sessions (e x b)	$ h		$ h	
	Total Overall Costs (f+h)	$		$	
	[1] Personell Computation should include a minimum of the number of oarticipants x average salary x employee benefits factor x projected number of days on project x daily meal expense x average daily travel expense				

Figure 1. Cost matrix

To comprehensively evaluate the costs effectiveness of online learning, practitioners and adopters need a comprehensive tool to evaluate the costs associated with online learning as compared to those associated with face-to-face learning. Figure 1 provides a cost matrix for the evaluation of these costs. The cost matrix is structured to be consistent with the basic Instructional Systems Design (ISD) model for training (Beckschi & Doty, 2000). Each stage of the ISD model (Analyze, Design, Develop, Implement, and Evaluate) is associated with a set of costs that would be relevant for the online leaning format, the face-to-face learning format, or both. An individual would consider the training intervention being developed, the number of times the training will be used with and without updates and the total number of participants anticipated. Using these factors along with knowledge of the technological infrastructure already in place within the organization, one can use this tool to make a comprehensive evaluation of the cost effectiveness of the proposed online training program.

Conclusion

This discussion has evaluated issues to be faced by the educational or training professional who intends to move the learning environment online in response to the current business and academic environments. Universities and corporations are in precarious economic positions at the current time with high emphasis placed on cost reductions in any manner possible. For this reason, the prospect of online education becomes a lucrative option, given that it does not require extensive travel costs or time by large numbers of employees and allows learners to participate no matter where they are located geographically. It is especially effective for those employees in small, remote office locations (Taylor, 2002). Online education has the benefits of scalability, easy access and timeliness, all of which are extremely desirable in today's economic climate (Clarke & Hermens, 2001). Centralization of education options creates new demands for modules that can affect the interests of learners in many different geographic locations and diverse international areas, requiring new forms of collaboration between the stakeholders in the training process and new ways for those in diverse geographic locations to share this information (Jakupec, 2000). The challenge is to transform a simple printed lesson transmitted via computer technology into an exciting online classroom with powerful interactive features for the learner. The education and training professional should recognize the opportunity afforded by online instruction to implement these new technologies so that the online environment is a rich and value-added teaching methodology.

Online instruction is gaining an increasing presence because of its reported benefits, its ability to consolidate learning across geographical and time constraints, and the claim by many that online learning is cost efficient. However, the education and training professional needs a tool with which to justify the development costs of online instruction. The metric provided here may prove helpful for making such determinations and it is introduced so that others may conduct quantitative studies on the matter of cost comparison using this cost matrix. This tool is intended to aid the education and training professional in many different ways. First, if those responsible for training wish to proceed with the implementation of online training systems, they will likely need a tool with which to justify the potential costs associated with such a program. Secondly, if those responsible for learning are under pressure to implement new online instructional programs, this tool may also provide an avenue to argue the point for necessary resources. Overall, the need for the financial justification of the conversion to online instructional programs is necessary. The cost matrix (see Figure 1) is a proposed tool to assist education and training professionals to begin discussion regarding costs associated with online programs in their universities or organizations. In addition, experimental evidence through continued study of comparisons of the benefits and costs of online and face-to-face instruction would be beneficial.

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Effects of Person-Centered Attitudes on Professional and Social Competence in a Blended Learning Paradigm

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Abstract

Web-based technology increases the hours we spend sitting in front of the screens of our computers. But can it also be used in a way to improve our social skills? The blended learning paradigm of Person-Centered e-Learning (PCeL) precisely aims to achieve intellectual as well as social and personal development by combining the benefits of online learning with face-to-face encounters. While the added value of Person-Centered or whole-person learning in terms of better problem solving, increased self-confidence and interpersonal skills is well documented in the literature, its transition into practice clearly lags behind. Our goal therefore is to exploit the potentials of Web-based support for making Person-Centered teaching and learning more effective and feasible. In the paper we discuss the didactical baseline, the integration of technology, and the application of PCeL in the context of Web engineering and project management. On that basis we present our evaluation that showed – with surprising clarity – the fundamental impact of interpersonal attitudes on the motivation and learning outcome of students. Finally, we discuss the consequences of our findings for future educational strategies.

Keywords

Student-Centered Learning, Experiential learning, Whole-person learning, Person-Centered Approach, Carl R. Rogers, Person-Centered e-Learning (PCeL), Evaluation, Staff development

The only man who is educated is the man who has learned how to learn […] how to adapt and change […]. Changingness, a reliance on process rather than upon static knowledge, is the only thing that makes any sense as a goal for education in the modern world. […]

The Carl Rogers Reader, chapter 21 "The Interpersonal Relationship in the Facilitation of Learning." p. 304; H. Kirschenbaum, V., L. Henderson, eds. Constable, London, 2002.

Introduction

A recent study on the required profile of business informatics graduates confirmed that social competence, the capability to work in teams, and abstract thinking are the top three requirements in the workplace. Although current trends in e-learning appear to respect the need for cooperative learning, online communities are devoid of personal encounters and the richness of face-to face situations where issues need to be resolved instantly. In a nutshell, there is accumulating evidence that neither traditional lecturing nor pure e-learning suffice to prepare students adequately for their future profession (Motschnig-Pitrik, 2002; Ryback, 1998). Hence, we conduct action research on shaping blended learning environments that employ technology in a situated way aiming to enrich didactic designs in which interpersonal encounters take the leading role in the learning process (Derntl & Motschnig-Pitrik, 2004a; Motschnig-Pitrik, 2004).

Several studies have shown that learning should encompass the whole person. More explicitly, this means that learning should address the learner's intellect, social skills, and personality. If this is achieved, learning is known to be most effective in terms of being best integrated with the experience of the particular person and hence more persistent than purely intellectual information (Aspy, 1972; Motschnig-Pitrik & Nykl, 2003; Rogers, 1961; 1983; 1995; Rogers & Freiberg, 1994). This paper approaches experiential, whole-person learning by proposing to combine Person-Centered Learning, as developed by the American psychologist Carl Rogers (1902-1987), with elements of e-learning, resulting in an approach we call *Person-Centered e-Learning* (PCeL) (Motschnig-Pitrik, 2001; 2002b; Motschnig-Pitrik & Holzinger, 2002). The primary benefits of PCeL, among others, follow from providing increased room for social and personal processes and deeper learning experiences. We will argue and illustrate that this can be achieved in the case when significant parts of the transfer of intellectual knowledge are allocated to the computer while the instructor takes on the role of a facilitator who creates a constructive learning climate based on values like transparency, respect, and understanding. Typically, learners elaborate selected topics in small groups, real or virtual, and bring together the individual perspectives in meetings of the larger group, resulting in conversations and transcripts that enrich existing expert knowledge with personal and group perspectives. In brief, PCeL courses offer a versatile range of possibilities for students to contribute and hence result in students (and facilitators) being remarkably more active than in traditional courses. In addition to cognitive gains, PCeL emphasizes social as well as personal or emotional learning and growth that, as will be argued, cannot be achieved purely cognitively but requires experience in a facilitative atmosphere (Barrett-Lennard, 1998; Motschnig-Pitrik & Nykl, 2003; Rogers, 1961). This approach is consistent with concepts like anchored instruction (Bransford et al., 1990; Cognition and Technology Group, 1990), collaborative learning (Bruffee, 1999; McConnell, 2002) and constructivist theories (e.g., Jonassen, 2004; Jonassen & Rohrer-Murphy, 1999). Yet it emphasizes the quality of relationships (Barrett-Lennard, 1998) and through them the development and growth of congruent intra- and inter-personal dispositions as a foundation of deep learning by the whole person.

In the next Section we briefly present the didactic and technical concept that underlies our applications and case-studies of PCeL. In the third Section we describe and motivate learning scenarios that spring from the philosophy of PCeL and state our basic hypotheses on the allocation of face-to-face and Web-based elements for effectively integrating intellectual, social, and personal learning (Nykl & Motschnig-Pitrik, 2002). In the fourth Section we discuss the results of the online questionnaires and reaction sheets that we collected in our courses on project management and Web engineering over a time period of one and a half years. The final Section then discusses the consequences of our findings and directions for further research.

Fundamentals of Person-Centered e-Learning (PCeL)

Preliminaries

Person-Centered Learning has been developed by the famous American psychologist Carl Rogers as a radically new approach to education that is applicable to learners of all age groups independent of their social background (Rogers, 1983). The theory underlying Person-Centered Learning is derived from Rogers' life-long experience in counseling, psychotherapy, facilitating encounter groups, and teaching at several universities. In his well-known book "Freedom to Learn", Rogers (1983) describes the concept and research foundation of Person-Centered Learning along with several applications in various contexts and subjects (such as French, Physics, Neuroscience, etc.) that appear highly illustrative and useful for the practitioner.

Our research at the University of Vienna, Department of Computer Science and Business Informatics, focuses on integrating Rogers' theory and experience with modern technology (Motschnig-Pitrik & Holzinger, 2002; Derntl & Motschnig-Pitrik, 2004a). In other words, we aim to enrich Person-Centered Learning with the use of New Media in order to make the blended approach more effective in primarily two respects. The first concerns a still further improvement of learning processes by adjusting Web-based technology to optimally support findings from psychology, sociology, and pedagogy. The second, and in our time increasingly important issue, deals with efficiency. From experience we know that Person-Centered "Teaching" is more demanding on facilitator's time than conventional courses that can be prepared once and reused several times. Regarding efficiency, we hypothesize, hope, and, to some degree experience that New Media, in particular the Internet, can be employed to reduce some of the overhead caused by the Person-Centered style. This is because the provision and dissemination of material, including artifacts produced by students, course organization, and personalization, are easier with information and communication technology (ICT).

The basic hypothesis underlying Person-Centered Teaching/Learning can be stated as follows:

Human beings are constructive in nature and strive to actualize and expand their experiencing organism. According to Rogers' Theory of Personality and Behavior (Rogers, 1959) the constructive tendency can unfold itself best in a climate that is characterized by three attitudinal conditions, also known as *Rogers variables*:

- *Realness*, with synonyms such as congruence, transparency, genuineness, authenticity;
- *Acceptance*, else referred to as respect, unconditional positive regard, caring attitude, concern for the individual, acknowledgement (Schmid, 2001);
- *Empathic understanding*, a deep form of understanding of the meanings as well as feelings of the learner.

These must be held or lived by the facilitator and communicated to the learners such that they actually can perceive them (Rogers, 1961). Based on extensive research in schools, Aspy (1972) argues that a Person-Centered style of teaching is effective only, if the instructor's or facilitator's level of all three attitudinal conditions lies above a threshold (being the level 3) defined by specific formulations in a questionnaire with 5 levels for each of the variables.

While it may appear that Rogers' approach is not compatible with conventional curricula, our own experiences in advanced courses are quite the contrary. Given a certain degree of space in the respective curriculum we have found that Person-Centered Learning, combined with the use of New Media, is a truly effective and rewarding approach which we chose to refer to as PCeL (Person-Centered e-Learning) (Motschnig-Pitrik & Derntl, 2002; Derntl & Motschnig-Pitrik, 2004b). In the following we formulate two hypotheses that we consider essential for blended learning. The first hypothesis follows immediately from adopting Rogers' findings and deals with personal attitudes and skills of facilitators. It can be stated as follows:

> *"The better facilitators communicate and learners perceive the attitudes of realness, acceptance, and understanding and the more transparent the whole setting is, the deeper will be the learning processes at all three levels."*

Clearly, PCeL requires qualifications of facilitators that essentially differ from those of good instructors in many respects. Besides skills for motivating students and delivering understandable lectures, facilitators need a high degree of inner flexibility to be able to react to individual situations in the here and now. They need to be able to respect individuals as well as the tendency of the whole group. They must be able to moderate discussions and visualize results, both in face-to-face meetings and in online settings. Most importantly, they must, in coalition with the learners, be able to find the right compromise between personal-, social-, and curricular requirements.

The second hypothesis includes the computer as a versatile tool. It can be stated as follows:

> *"In the case that the computer can take over significant parts of the transfer of intellectual information, more room will be left for social and personal learning in a facilitative climate."*

If pure transfer of information is no longer the focal point in face-to-face meetings, they can be used to anchor knowledge to existing experiences of the learners, to the exchange of learners' viewpoints and/or materials, to discussions of expert meanings, to applications, etc. In this way learners will be more active personally and will be able to experience working/learning in teams that construct knowledge. Later, this knowledge can be compared with expert meanings and overlaps as well as deviations provide valuable sources for sharing and dialogue.

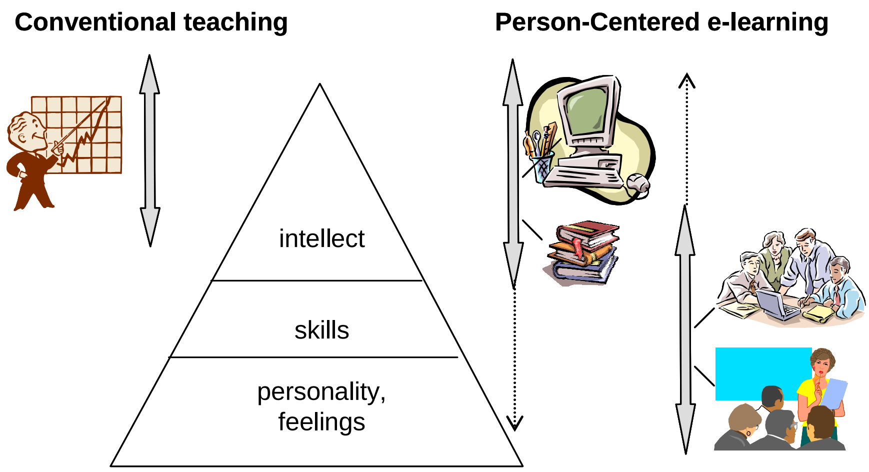

Figure 1. The three levels of learning and their primary support by facilitators and computers

Figure 1 illustrates this conception of PCeL by comparing it with conventional learning. The vertical arrows indicate the primary focus regarding the individual levels. Whereas conventional teaching addresses first of all the intellect, and the instructor is the one who sets targets and engages in the transfer of information, PCeL propagates to all three levels. Thereby, computerized support, initially complemented by other resources, may dominate on the intellectual level by striving to optimally support the cognitive, time-based, and location-based requirements of the individual learner. Although learning communities and social knowledge construction can be supported by ICT, we allocate learning at the social level more strongly to the presence phases, as far as traditional university courses are concerned. In such courses, various face-to-face settings are arranged to allow for team meetings, group discussions, presentations of students or the facilitator, meetings with experts, etc. In any case, we see real, acceptant, and understanding relationships as the driving factors in whole-person learning.

We also strongly believe and have initial qualitative evidence that the more intellectual information is available in electronic, well organized, structured, and searchable form, the more effective PCeL will become. This is because the strongly individual and open style of the Person-Centered Approach that establishes the affective basis is well supported by an open repertoire of resources and tools to be most effective. We have observed that easy availability of material eases the facilitator's task of organizing material and gives (advanced) students still more opportunities to satisfy their curiosity by finding sources that suit their interest and style. We have observed that, if left with a choice, students tend to search the Internet and integrate self-found resources into their project work rather than strictly keeping to the reading lists provided by facilitators.

Before giving empirical evidence and qualitative arguments to support our hypotheses, we invite the reader to learn to know the basic ideas and principles underlying PCeL.

Characteristics and goals of Person-Centered Teaching and Learning

Person-Centered, or Student-Centered Learning is a personally significant kind of learning that integrates new elements, knowledge, or insights to the current repertoire of the learner's own resources such that he or she moves to an advanced constellation of meaning and resourcefulness (Barrett-Lennard, 1998). Person-Centered Learning can be characterized by the following goals (adapted from Rogers, 1983, p. 3, and complemented by ideas borrowed from Barrett-Lennard, 1998, p. 187-188):

- a participatory mode in all aspects of learning and decision-making, furthering and experiencing self-responsibility for learning and for assessing gains;
- a climate of trust in which curiosity and the natural desire to learn can be nourished and enhanced;
- helping students to achieve results they appreciate and consider worthwhile and inwardly meaningful, such as to build their self-esteem and confidence;
- uncovering the excitement in self-initiated discovery, which leads students to become life-long learners, fosters originality, and brings out the creative potential of the individual;
- developing in instructors the attitudes of realness, authenticity or transparency; acceptance or respect and empathic understanding that research has shown to be most effective in facilitating learning;
- helping instructors to grow as persons finding rich satisfaction in their interactions with learners and thus increase their personal resourcefulness;
- Increasing a person's capabilities to experience and explore his or her own processes, thus raising the awareness of meaningful ways of inquiry, in other words, learning how to learn. This generic meta-capability enhances the person's disposition to successful problem solving in new and unforeseen situations.

The Student-Centered Approach to teaching and learning is one of the derived theories of Carl Rogers' Theory of Therapy, Personality and Interpersonal Relationships (Rogers, 1959). Consequent research in the Student-Centered Approach proved (Aspy, 1972; Cornelius-White, 2003; Rogers, 1961; Tausch & Tausch, 1998) that students achieve superior results along with personal growth in terms of higher self-confidence, creativity, openness to experience, self-respect, and respect towards others and their environment, etc., if they learn in an atmosphere or climate in which the facilitator (instructor, teacher, etc.) holds three core attitudinal conditions and if they perceive them, at least to some degree (Rogers, 1961). While this may sound easy, concrete situations (e.g. curriculum requirements, critical students) often are challenging for instructors to find the proper proportion among the three dispositions in the context of external requirements. Person-Centered courses depend not only on the instructor's plans but due to their participatory mode bear in themselves the unexpected, the chance to learn from situations in the "here and now", that requires a large amount of internal flexibility in both facilitator and students. Consequently, as will be discussed in the fourth Section, personal resourcefulness of the facilitator has significant influence on the students' motivation and learning.

PCeL: Integrating Person-Centered learning with technology

The old rule in teaching: prepare once and use several times simply does not apply, if students are to participate in all aspects of learning. Clearly, facilitating significant learning requires extra effort, at least initially: Time to think, to communicate, to structure, and organize contributions in order to make them effective for the whole group, to provide special material, and, time and commitment to acquire the skills necessary to shift from being a good instructor to becoming a good facilitator of learning. In the following let us see in which ways technology can help to reduce some of the extra work inherent in facilitating Person-Centered Learning.

- **Provision of resources via the Internet or the e-learning environment.** Lecture notes, reading lists, links to professional Web sites and project homepages can be made available electronically. The material can be uploaded and updated whenever deemed necessary. Students can contribute to searching material and making it available for the whole group, optionally with comments on contents, quality, and/or availability. This saves some of the facilitator's time for dealing with versions, organizing copies, searching material for individual purposes, and the distribution of material. In the case that all resources are well organized in one place, all participants can appreciate the flexible availability of material around the clock and independent of a physical location. Learners can take on responsibilities for various issues regarding the virtual learning space thus encouraging self-organization.
- **Course homepage and Internet as knowledge sources.** Locality of all organizational/structural information regarding the whole course as well as the provision of organizational information on individual course units makes communication more efficient in the case that students regularly read that information. Computer science students in particular and other students in general can use the Internet for explorative, open learning (Freimuth, 2000). This learning paradigm is particularly suited to the Person-Centered Approach since students are free to explore the semantic Web and can cooperate in fulfilling their tasks. Our experience is constrained to working with rather advanced students. Beginners may need some support in effectively searching the Internet, although this could change as time proceeds.
- **Communication and participation**. The Person-Centered Approach with its orientation towards the students' interests and participation in all aspects of learning necessitates intensive communication between all concerned (Rogers, 1970). In this respect, a learning environment provides means (discussion forum, students' workspaces, blackboards, whiteboards, etc.) to facilitate and to focus communication. Results from project work and from face-to-face meetings can be distributed easily by individual participants with just minimal involvement of the facilitator. Also, student tutors can help to answer and/or screen questions and help to save the facilitator's time.
- **Evaluation**. Continuous cooperation that is traceable by special programs and Web-based self- and peer evaluation make final tests and exams superfluous in many cases. Final meetings with students or small teams tend to be used more strongly to reflect on the whole course experience and personal learning, based on self- and peer evaluation, than on recalling course content.
- **Templates for Person-Centered e-learning**. We are deriving and developing Web templates to provide effective organizational support for characteristic, application-independent patterns of PCeL elements. Learning scenarios that have proven successful in practice are modeled, managed in a pattern knowledge base, and implemented by wizards and prefabricated Web application fragments (Derntl & Motschnig-Pitrik, 2003; 2004b). Initial experience shows that Web applications resulting from instantiating templates considerably reduce the organizational and administrative overhead of PCeL courses. The Web applications we are constructing (CEWebS, Cooperative Environment Web Services – cf. Derntl & Mangler, 2004; Mangler & Derntl, 2004) are open-source, high-level, intuitive and highly usable modules or molecules that build on lower-level, traditional e-learning elements or atoms. The elaboration, acquisition, and construction of patterns ideally would bring educators from various organizations together and could serve as a basis for staff development as well as research regarding situated media-didactical competencies. Ideally, such meetings would be facilitated in a Person-Centered style.

In our experience, PCeL courses still take more of the facilitator's time than conventional courses, but the overhead is clearly outweighed by the intellectual, social, and personal gains of the participants. Moreover, we conjecture that increased experience with the new style will reduce some further fraction of the overhead. Unfortunately, we cannot give quantitative data on the amount of overhead in PCeL courses since we conduct many of them as action research studies to which we devote more time and effort than would be necessary otherwise. As mentioned before, expertise needs to grow incrementally. Personally, we perceive a decrease in extra effort due to emerging patterns and more familiarity with the options offered by the Web-based learning platform. This goes hand in hand with an increase in providing freedom and trusting our spontaneous responses rather than over-preparing individual units.

Expression of Rogers' Three Core Conditions in Blended Learning Environments

Due to the significance of the three core conditions in any growth-promoting relationship, we are in the process of searching for ways on how to express and manifest them in the context of learning situations. In other words, we suggest general learning scenarios that can be seen to accompany and manifest the corresponding attitudes. These scenarios are supposed to have a Person-Centered atmosphere at their core while encompassing rich dialog, team- and individual activities, various materials, tasks, resources, problem-based learning processes and computer-mediated communication in ways that encourage cooperative, self-initiated learning. In the following, we express each core condition in terms of learning situations that allow one to communicate or carry on the underlying attitude and illustrate the result by individual student's reactions.

Realness

In learning situations, realness (authenticity, openness, transparency) as an attitude should go hand in hand with letting learners solve real, authentic problems that they themselves find worthwhile or even fulfilling to resolve. In our experience, some of which will be reflected in quantitative terms in Section 4, allowing students to solve authentic problems (e.g., designing their own cooperative environment, building a Web application for their Tennis club, etc.) increases their motivation, personal involvement, learning and achievement, time spent on the project, and also the total satisfaction as a result of the course. A student writes in his reaction sheet:

> "*I found working on our own project really cool. You can even avoid the stress in the final weeks if you keep to your work plan! – Many thanks.*"

Another notion that symbolizes realness or transparency is the provision of open reactions or constructive feedback. Students are encouraged to comment on other participants' or teams' contributions such as their oral presentation or their written projects milestones. They also are asked to write reaction sheets on face-to-face units such that the (electronic) comments are exposed to the facilitator and, via Web based services, to all other participants. This allows the facilitator to "view the whole picture", to see where he or she stands at the moment, and to discuss the comments, complaints, wishes, confusions, expectations with the learners in the next face-to face meeting. This mode of reflection and reaction – distant and present, respectively – definitely contributes to raising the level of transparency in all aspects of the course. One female student writes in her reaction sheet:

> *"What I also liked was that the reaction sheets were discussed with the students. In most other courses, you are asked to evaluate the course in the end. Afterwards one does not know what this was good for and does not get any information about the results. Talking openly about the reaction sheets let me feel that we all as the whole group of students were taken seriously and were respected."*

The Internet opens up yet another dimension of transparency: Since space is almost unlimited, all projects and solutions can be made visible for the whole group, such that everyone can learn form more than their own project or example. Comparing, copying, discussing, and most of all, cooperating and revising are encouraged rather than punished. In a facilitative climate experiences are shared and paths to improvement, rather than mistakes, are sought.

Acceptance

In cooperative learning situations there exist vast possibilities to show acceptance or respect to students. Once they are offered the option to participate in shaping (parts of) the course, for example by encouraging the expression of their individual learning targets and taking them into account, they are already trusted to be able to co-shape their course. Thus, genuine participation and any offer to participate in decision making are symbolizations of respect towards the learner. Similarly, encouragement of self-initiated action and any other form of providing freedom can be seen as respecting the other person as someone of individual self-worth, irrespective of the current level of knowledge but with respect to the learner's potential development (Rogers, 1961; Vygotsky, 1982) at his or her own pace, constrained solely by the requirements of the respective curriculum.

A student writes in his reaction sheet:

> *"The open atmosphere in all presentations made this unit an event of rare occurrence in the context of the university. Although we did not have a precisely defined topic and fixed requirements, I think I am learning more than in other courses. […] This course, with all its openness and the possibility to*

make mistakes without negative consequences allows one to learn in a way that is not possible in any other course at the university."

Besides providing freedom, shifting power and influence from the instructor to the participants can be perceived as signs of trust based on acceptance. Concretely, the situation of course evaluation or evaluation of any document or contribution lends itself very well to shifting power from the instructor to the group or individual who participates in the grading process by self- and/or peer evaluation. Our preferred mode is to give equal share to self-, peer-, and instructor evaluation such as to make the grading process as multi-perspective and informed as possible, showing respect to the individual, the group and the instructor's own perception.

In learning situations as well as in management there appear to be two opposites of an accepting, respectful, caring style: authoritarian and laissez-faire attitudes. While strict control imposes external, fixed conditions or values on what is acceptable, a laissez-faire style is passive, lacking the communication of caring and respect. Cooperative learning groups, on the contrary, allow for intensive communication among peers and, if working in a facilitative climate, appear to be particularly strong in allowing for a high degree of caring or respect among learners. This applies even in settings with large numbers of students that otherwise would call for rigidly prescribed tasks or exercises to be solved by students.

In particular, we found learning contracts highly practical for bridging the gap between curricular requirements and self-initiated and self-directed learning. They allow students to take on responsibility in an open-ended learning space, where success can be approached in an incremental fashion, very much like in an industrial project. Thus, learning becomes a transitional experience between complete freedom to learn whatever is of current interest to the learner, to evidently respecting the course- and curriculum requirements. Our online support of managing and peer- and self-evaluating learning contracts of cooperative teams of students illustrates in which ways technology and humanistic educational principles can be brought together in order to make learning more meaningful and yet manageable in terms of effort. Interestingly, although the learning contracts (to be revisited in the fourth Section) required some additional effort, they were perceived as much more meaningful than conventional exams. All four participating instructors agreed on repeating the experience in the coming term.

Understanding

In learning situations empathic understanding comes in multiple manifestations. Certainly it involves a deep understanding of the whole situation and learners' meanings, purposes, constraints and potentials. It means seeing projects and problems from the learners' state of knowledge and frame of reference and a willingness to accompany the students in their ways of searching for solutions rather than just imposing prefabricated recipes on them. Facilitators' contributions, for instance materials, presentations, tutorials, need to meet the students' demand of knowledge or techniques to solve problems, not vice versa. Importantly, understanding also encompasses patience in periods of following rather than leading (Schmid, 2001) and yet at every instant watching out for moments of insight. To facilitate whole person learning as intensely as possible in order to promote personal and intellectual growth, it is essential to react to and exploit particular situations from the here and now. This requires the facilitator to empathetically take into account the whole situation of the particular course and community of learners for course design.

Naturally, deep understanding involves the clarification of uncertainties. However, there is evidence (Anderson, 1991) that understanding based on seeking and finding solutions in a way comparable to an internal, conceptual birth process is much deeper and more persistent that flat understanding in the form of rigid constructs delivered by some external source or authority. Person-Centered learning means listening to the learner, in order to accompany him or her towards a learner-driven clarification of uncertainty. This is equally important for understanding cognitions, purposes, meanings, and feelings, focusing on the aspect that is pivotal to the recipient in the current situation.

In blended learning written materials tend to play a significant role. In this respect, Tausch and Tausch (1998, pp. 266-277) have found four aspects or dimensions for the understandability of written materials: Texts should be well structured, neither too lengthy nor too concise and use simple language while revealing the essential message. Furthermore, stimulation should be provided for example by giving examples, citations, narratives, including pictures, etc.

Evaluation in Courses on Web Engineering and Project Management

The gross goal of the project management courses can be stated as: "*Participants should be better qualified to accomplish effective project work in teams*". This general goal can be decomposed into sub goals situated on three levels. On the intellectual level, students should learn strategies and techniques for managing information and communication technology (ICT) projects. On the level of social skills, participants should experience working with various colleagues in teams of various sizes, and improve their communication and presentation skills. On the personal or intuitive level, students should observe and perceive Person-Centered attitudes in action and derive their own experience. Although the basic structure, thematic context ("Communication, motivation, leadership, and cooperation in project management"), and the gross goals of the practical course module were predefined by the instructors, the emphasis and individual learning targets, topics, and processes – not surprisingly in light of PCeL philosophy – turned out to be different in the four course instances. The e-learning platform, in this course, served mainly to supply intellectual and organizational information, as well as to provide a repository for students' projects. In the presence phases we elaborated and discussed topics, students presented their projects and lecturing was kept to a minimum.

An example of a technique that we tried out in a meeting was "active listening" in triads. Vivid arguing evolved around the question on what place active listening has in discussions where everybody should be able to bring in his/her opinion. Students comment on this exercise in their own words:

> *"In this unit I particularly liked the exercise of 'active listening'. I had known this concept already, but only through applying it concretely to a particular situation could one pay attention to the individual issues involved and could change perspectives."*

> *"I found the 'active listening' exercise particularly formative. It is an approach about which I had absolutely no idea before, but that I experienced as highly interesting. This is mainly because it is not relevant only for team- and project cooperation but also for everyday life."*

In order to make it possible to learn from the students' experience in this quite novel course format, every student had to hand in a reaction sheet after each workshop. The format was essentially free, although a catalog of sample issues of interest was provided by the Internet for those who wished some guidance. In the final group, all reactions have been published via the e-learning platform, although in an anonymous form. In the end of the last workshop, students were also asked to work out some questionnaires such as the Person-Centered questionnaire or the official evaluation sheet of the University of Vienna.

To get an objective picture on the particular realization of PCeL in the context of the practical course on soft skills in project management, all reaction sheets of the 56 participating students (note that there were actually four concurrent groups) were evaluated. On the average, each student delivered 10.49 comments or statements. Katharina Mallich, taking the role of an independent evaluator, graded the individual statements with three grades, namely 1 denoting "*I liked it/ it was positive*", 2 saying "*neutral, could be improved or modified*" and 3 standing for "*I didn't like it/ it was negative*". The results of the most frequent statements are sketched in Figure 2. The most frequently mentioned comments referred to the multitude of practical exercises which were stated 75 times during the three workshop units with a score of 1.13 from three possible points. Also very frequent (48 times) positively valued (1.05 points) was the new and innovative manner of the course and the pleasant and relaxed atmosphere which was mentioned 39 times and scored with 1.16 points. Information about structure and processing of the workshop was rated 34 times as relatively good with 1.63 points. Between 28 and 30 times students considered their active inclusion and co-operation with colleagues very positive, in particular the insightful discussions, the phases of feedback and the initial presentation of each other. This introduction contributed to the friendly atmosphere of the courses and stimulated much co-operation inside the whole group. The only problem that recurred during the workshops in two groups concerned a discussion of recording the lessons on a cassette recorder.

Apart from the reactions on recording, all frequent students' comments were evaluated as generally positive. In our view, it remains an open issue, whether situations like the one with the recorder improve or deteriorate the quality of a course. The response may depend on the number of such situations, the quality or sensitivity regarding the way they are handled by the facilitators, and the students' personalities.

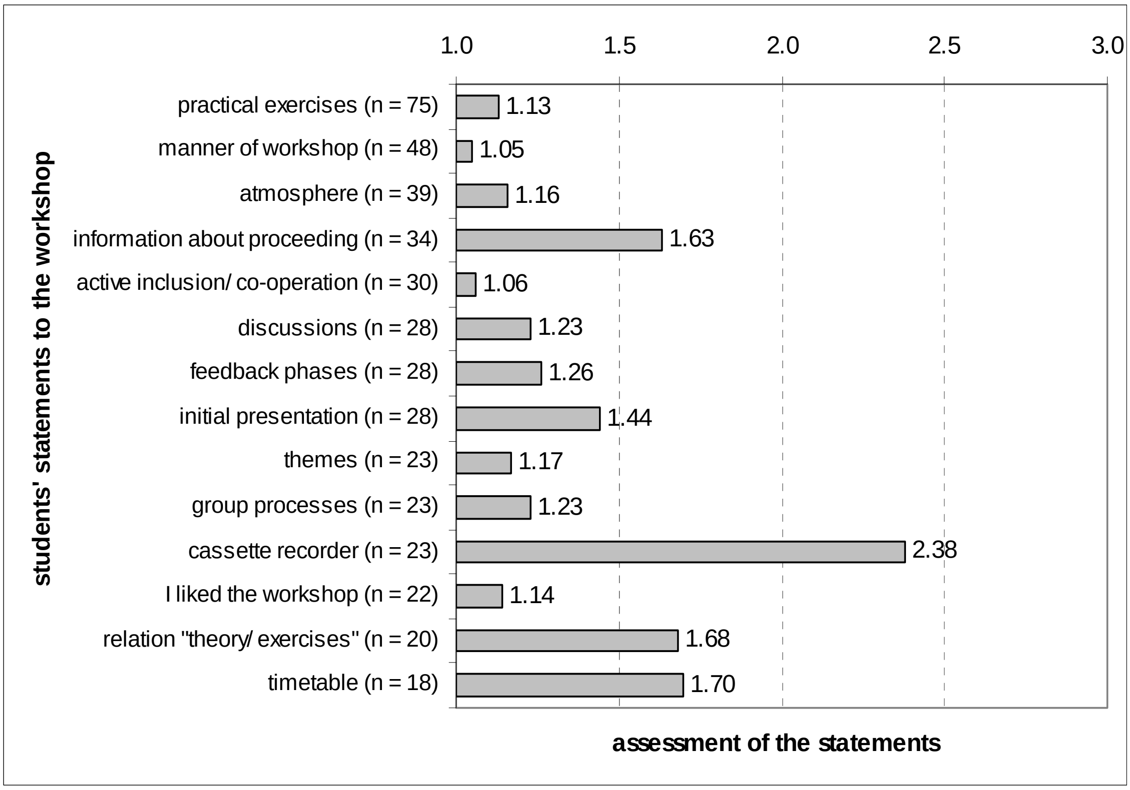

Figure 2. Most frequent statements and their evaluation on a 3 point scale; 1=*positive* … 3=*negative*

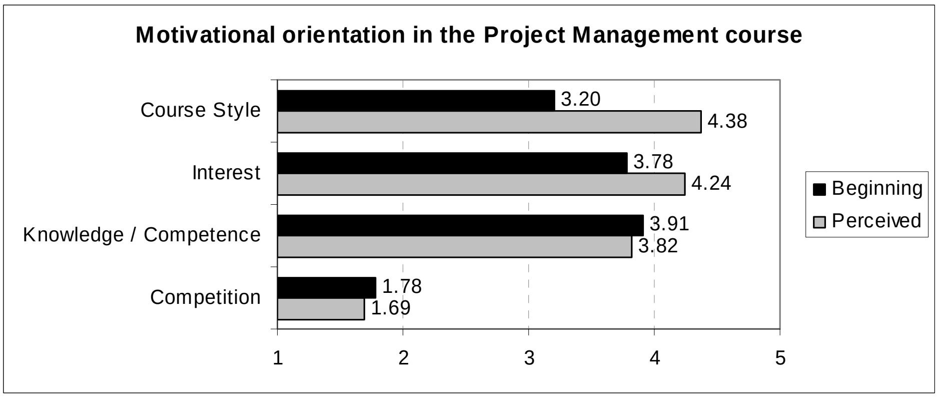

Figure 3. Motivational orientation for a typical course ('Beginning') compared with the course on Project Management ('Perceived'); n = 15; Scales: 1 stands for 'does not apply at all', 5 means 'applies highly'

In order to gather some more objective data on our course in the following term we asked students to respond to an online questionnaire with about 60 questions. Out of 28 students (from two parallel courses), 15 submitted the questionnaire both in the beginning and in the end of the course. 22 questions concerned the motivational orientations of students such that in the beginning of the course, students were asked about their motivation to attend a typical course due to motivational factors such as interest, competence, competition, and course style. In the end the questions concerned the students' participation in the project management course (PM-2003) due to these factors. As can be seen from Figure 3, the major motivation for students to attend a typical course was to increase their knowledge and competence in the subject area (with a mean value of 3.91), whereby the increase in factual knowledge was expected with a mean value of 4.2 and the practical elaboration of material just with 3.27 (not shown in the Figure). The motivation by knowledge and competence was followed by the motivation by interest in the subject matter and by the course style. After having attended the course on project management, the students' motivation with respect to competence and knowledge stayed about the same (in fact it was decreased for acquiring factual knowledge and increased for the practical elaboration), whereas their motivation due to the particular course style (to be discussed below) increased significantly from 3.2 for a typical course to 4.38 for the PCeL style course! Also, the motivation due to interest in the course's subject matter has been increased from 3.78 to 4.24, while the importance of competition stayed low. As will be discussed below, these results were reproduced in a course on Web engineering with a larger sample size, but only in those groups in which the instructor was perceived as highly real, acceptant, and understanding. In all other groups, no single motivational orientation could be increased significantly as a consequence of the course, although the gross course structure and technology support stayed the same for all instructors!

Before moving to the evaluation of the Web engineering course, let us look at the individual factors contributing to the course style cluster. The expected and perceived values of the course-style factors are given in Figure 4 which illustrates the importance of providing a constructive learning climate. In fact, the positive atmosphere was perceived as highest (mean value M = 4.67 on a 5-point scale) among all motivational factors in the course PM-2003, followed by the collegial cooperation among peers (M = 4.53)! The largest difference in motivation (between a typical course with M = 2.27 and PM-2003 with M = 4.33), however, was achieved in the factor 'active participation of students', followed by allowing time for discussion.

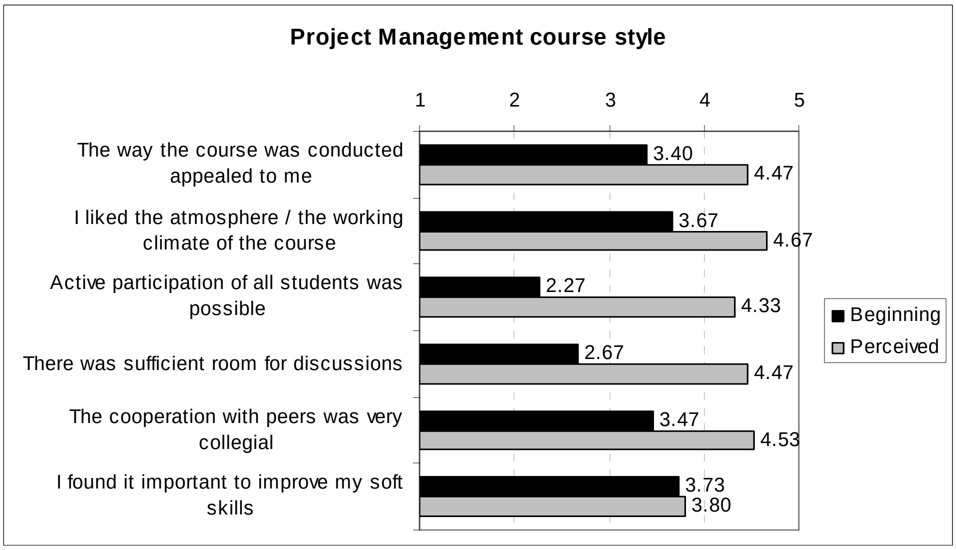

Figure 4. Motivational orientation due to various factors regarding the course style for a typical course ('Beginning') compared with the course on Project Management ('Perceived'); n = 15

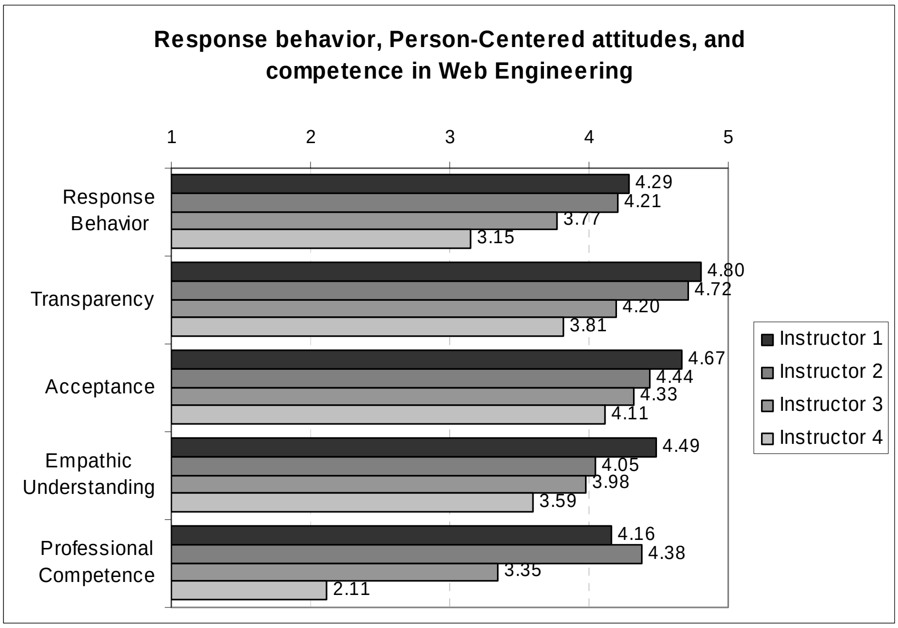

Figure 5. Response behavior, Person-Centered Attitudes and competence of four instructors in the course on Web Engineering WE-2003 ($n1$ = 47; $n2$ = 39; $n3$ = 47; $n4$ = 27)

While project management was a course that was held in a seminar room with group size about 17 students, the Web engineering (WE) course took place in a computer laboratory and group size was about 30 students. It seems particularly thrilling to compare the empirical evaluation of these two different settings, in particular in investigating the influence of Rogers' core conditions on students' motivation and learning outcome across groups of different instructors of the course WE-2003. In WE there were 12 groups such that each instructor conducted two to four groups. Figure 5 lists the students' ratings of the four instructors regarding their response behavior, realness, acceptance, understanding, and competence in the subject matter. In this context note that 'instructor 1' of Web engineering was the same person who conducted the courses in project management. It is noteworthy that there were no significant differences in her ratings between Web engineering and PM-2003 regarding the attitudes listed in Figure 5, although differences between the four instructors of Web engineering tended to be statistically highly significant.

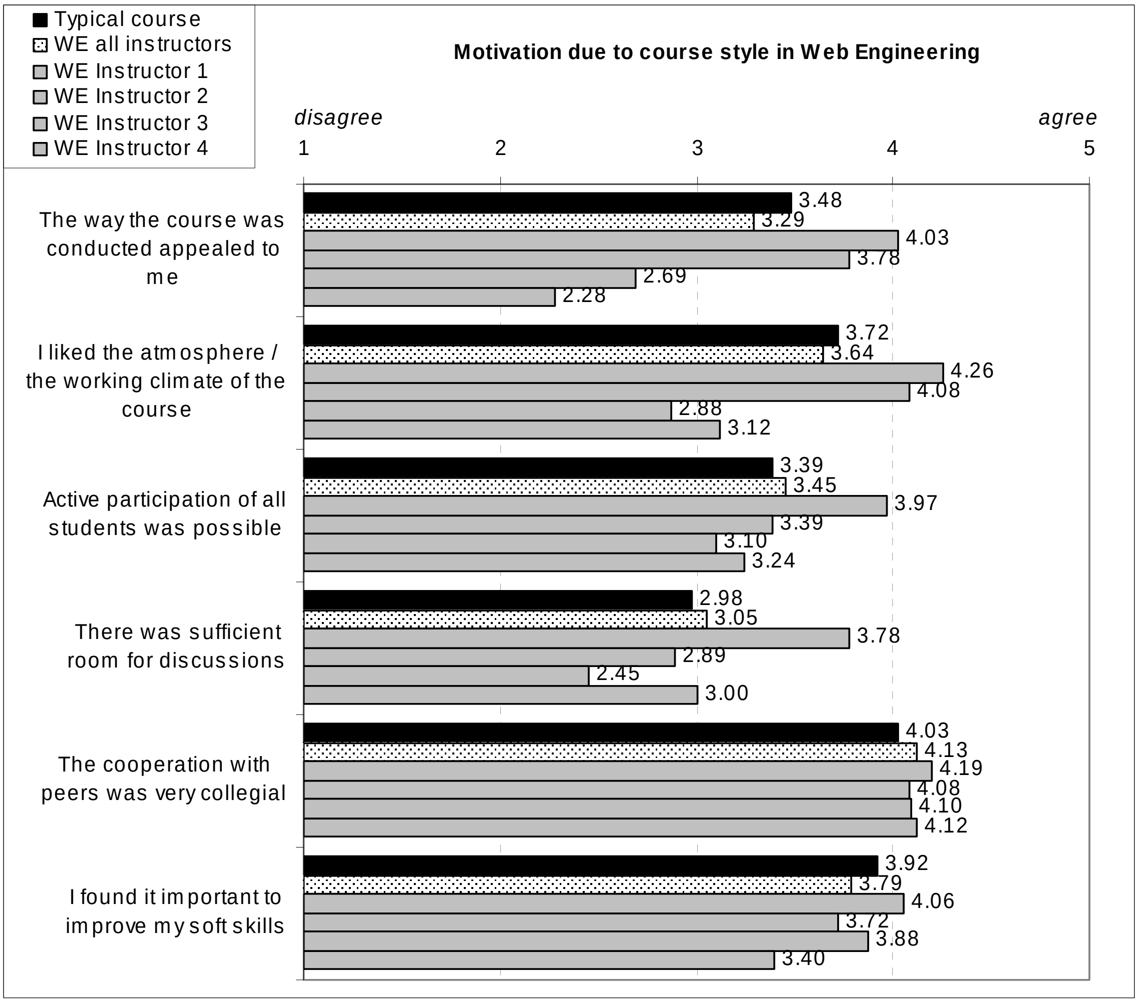

Figure 6. Motivational orientation due to various factors regarding the course style for a typical course ('Beginning'; *n* = 131) compared with the course on Web Engineering (*n1* = 38; *n2* = 36; *n3* = 32 ; *n4* = 25)

There were no statistically significant differences regarding students' expected and the perceived motivation to participate in a typical course and Web engineering, except for competition. In Web engineering, students typically cooperated more and competed less. However, comparing the expected and perceived motives to participate in Web engineering with respect to groups of the four instructors, motivation due to the course style was increased in groups of instructors 1 and 2, who were ranked high in Person-Centered attitudes. In groups of instructor 1 the increase was statistically highly significant as shown by a paired t-test ($t = -3.60$, $p = 0.001$, $n = 35$). Also, in groups of instructor 1, motivation due to students' interest in the topic was higher ($M = 4.31$) than in comparable typical courses ($M = 3.97$). The results of a multivariate ANOVA (compare Table 1) showed further significant differences between the four instructors in Web engineering.

Table 1. Motivational orientations of students: Analysis of variance with instructor as independent variable and the motivational orientations as dependent variables

Dependent Variable	*F*	*P*
Course-style-orientation	9.90	p ≤ .001
Interest-orientation	4.54	p ≤ .001
Competence-orientation	3.00	.03
Competition-orientation	1.47	.23

(df = 3; numbers of participants: instructor 1: n = 62, instructor 2: n = 66, instructor 3: n = 77, and instructor 4: n = 47; ntotal = 252)

Looking for the concrete factors that contributed to the differences in motivation between typical courses and Web engineering, Figure 6 shows that, precisely as in the course on project management, the positive atmosphere proved to be the strongest of all motives related to the course style (with a mean of 4.26), followed by the collegial teamwork with peers (M = 4.19). Unlike in project management, however, the strongest of all motives to participate in Web engineering was to increase one's professional competence and the interest in the provided content (both ranked 4.31 in groups of instructor 2 and instructor 1, respectively). Next followed the positive working climate (M = 4.26 in groups of instructor 1), as depicted in Figure 7. Statistically, however, the slight differences between these motives are not significant. Consequently, there is a strong indication that instructors with high Person-Centered attitudes and sufficient competence in the subject matter are capable of keeping or even increasing students' motivation along factors distributed on all three levels of learning. In other words, all three contribute highly to students' motivation to participate. It also follows, that some aspects of motivation are decreased by instructors who are perceived as being just about average in Person-Centered attitudes. It is remarkable that these changes in motivation are brought about in courses with just two hours per week over the period of one semester! A further consequence of our research is almost astonishing in how precisely it supports Person-Centered theory: The increase in motivation goes back, in the first place, to the instructor's capability of providing a positive working climate where, furthermore, students can participate actively. Given the instructor is perceived as highly real, respectful, and understanding, the positive climate is perceived by students as being among the *top three motives* for participating in the course.

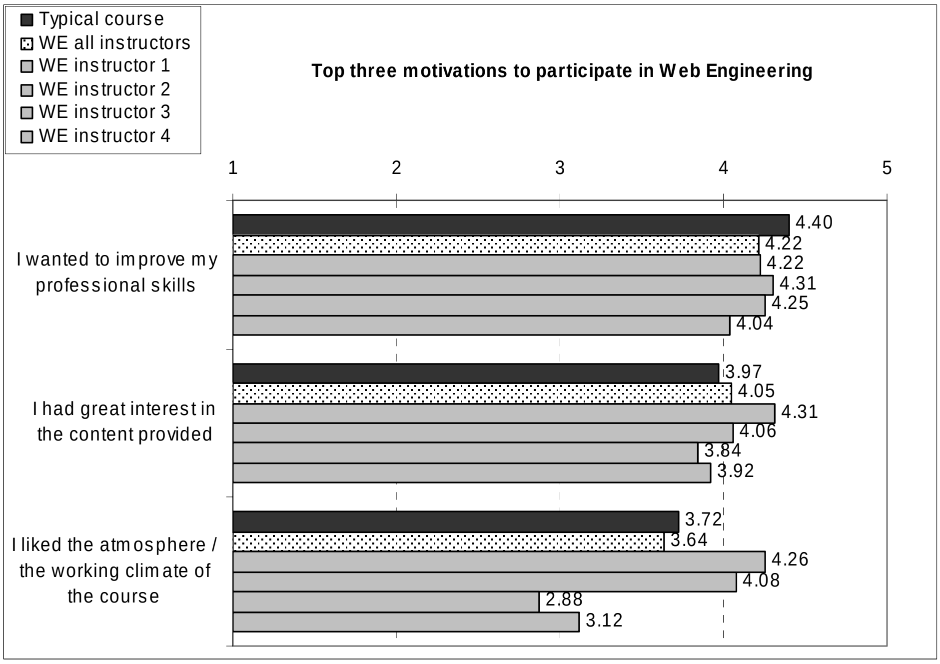

Figure 7. Top three motivational items in a typical course (*n*=131) compared with groups of the four Web Engineering instructors (*n1*=38, *n2*=36, *n3*=32, *n4*=25)

In Web engineering 84% of the students decided to cooperate on constructive work rather than take the exam. It was clear from the outset that a major goal was self-initiated, cooperative teamwork and learning with an emphasis on communication, reflection, and a critical, application-dependent selection of techniques. With these goals in mind, we suggested a learning contract like project: the *Web Engineering Learning License* (WELL) to be offered to students in order to provide them with the option to engage in self-directed constructive work rather than take a conventional exam, which was offered as an alternative.

In a reaction sheet, one student writes:

> "*First of all I'd like to mention that WELL is a great idea. Often it is the case that one hears and learns the material in a lecture, but does not really understand it, because one doesn't have the time to go into all topics of the lecture. Nevertheless, I have some suggestion regarding the proceeding of WELL. Comparing the individual contributions one sees that they differ strongly. It might be wise to prescribe some format and rules, such as minimal and maximal page number, base structure of the contents, structure and expected number of citations, layout, etc…*"

Another student mentions briefly:

> "*In this course you see that it is possible to give free space for students, even if the requirements are of a precise nature. Of course, the WELL contracts contributed to having more contact to the students (but also caused more work)*".

Yet a third one comments:

> *"I find the idea with WELL cool, because I can avoid the stress during the last weeks of June, if one does the time management more wisely than we did. Many thanks."*

In addition to online reaction sheets we have conducted an empirical study confirming that 72.8% of the students who participated in the WELL project valued its long term learning effect as higher (41.9% much higher and 30.9% somewhat higher; cf. Figure 8) when compared to taking a conventional exam. Additionally, 64% of the participating students considered the engagement in the WELL project as more time-intensive. We emphasize that the values reported here stem from our first approach to this novel form of assessment and we intend to improve several aspects of WELL contracts, based on our initial learning.

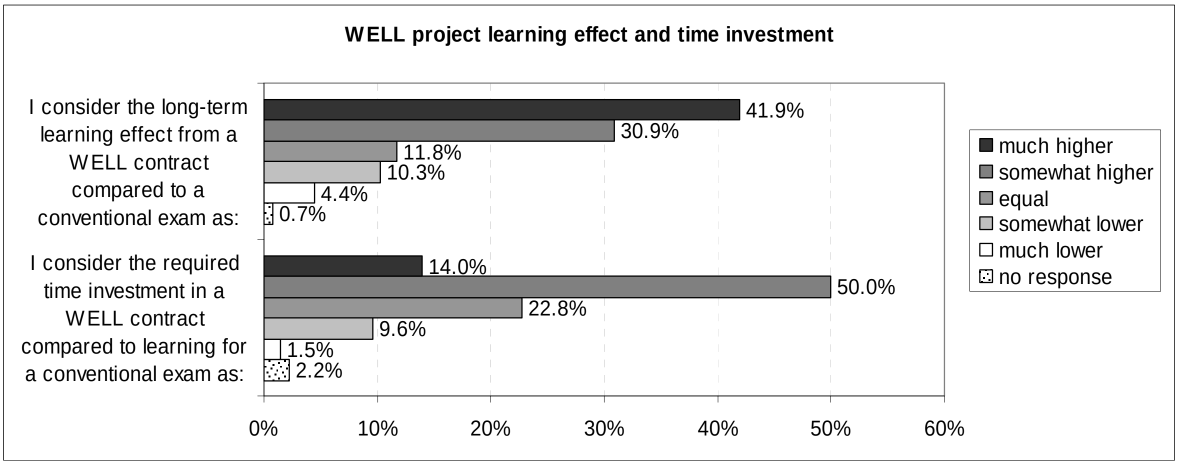

Figure 8. Long-term learning effect and time investment perceived by WELL participants compared to conventional exams (n=136)

Another statistically significant difference we measured concerns the learning outcome in terms of project work. Individual projects were peer evaluated such that each student (out of 299) was supposed to evaluate at least three projects of his or her choice. During this evaluation he or she could distribute 1 to 5 bonus points to each project he or she reviewed. Interestingly, the weighed received bonus points of students participating in groups of instructor 1 accounted to 46.94, whereas the average points for groups of instructor 2 to four were less than 38.33. This indicates a clear trend but further research is necessary to prove the influence of the three core conditions on achievement in projects.

Finally, Figure 9 lists students' estimates on individual skills they acquired in Web engineering, depending on their instructor. The topmost bar depicts, respectively, the students' estimates for skills acquired in a typical course, as indicated in the beginning of the term. It is well known that these estimates tend to be more optimistic when compared with estimates in the end of the term, where students are amidst exams and hence less relaxed

(Rogers & Freiberg, 1994). In any case, we find it interesting to observe that in Web engineering, unlike in typical courses, students profited slightly less regarding factual knowledge. Note, however, that the difference is statistically significant only for the instructors who were estimated lower in Person-Centered attitudes. Significant gains in Web engineering were perceived to concern practical competence, the production of work documents, and the importance of interpersonal relationships, in groups of instructors who were perceived as high in Person-Centered attitudes. These results strongly confirm our initial hypotheses. Firstly, they illustrate that learning on three levels is improved by instructors who are perceived as real, respectful and understanding. Secondly, they show that in a blended learning design, where the computer takes over parts of the transfer on information, more space is left for social and personal learning and this space is transferred into perceivable learning and growth.

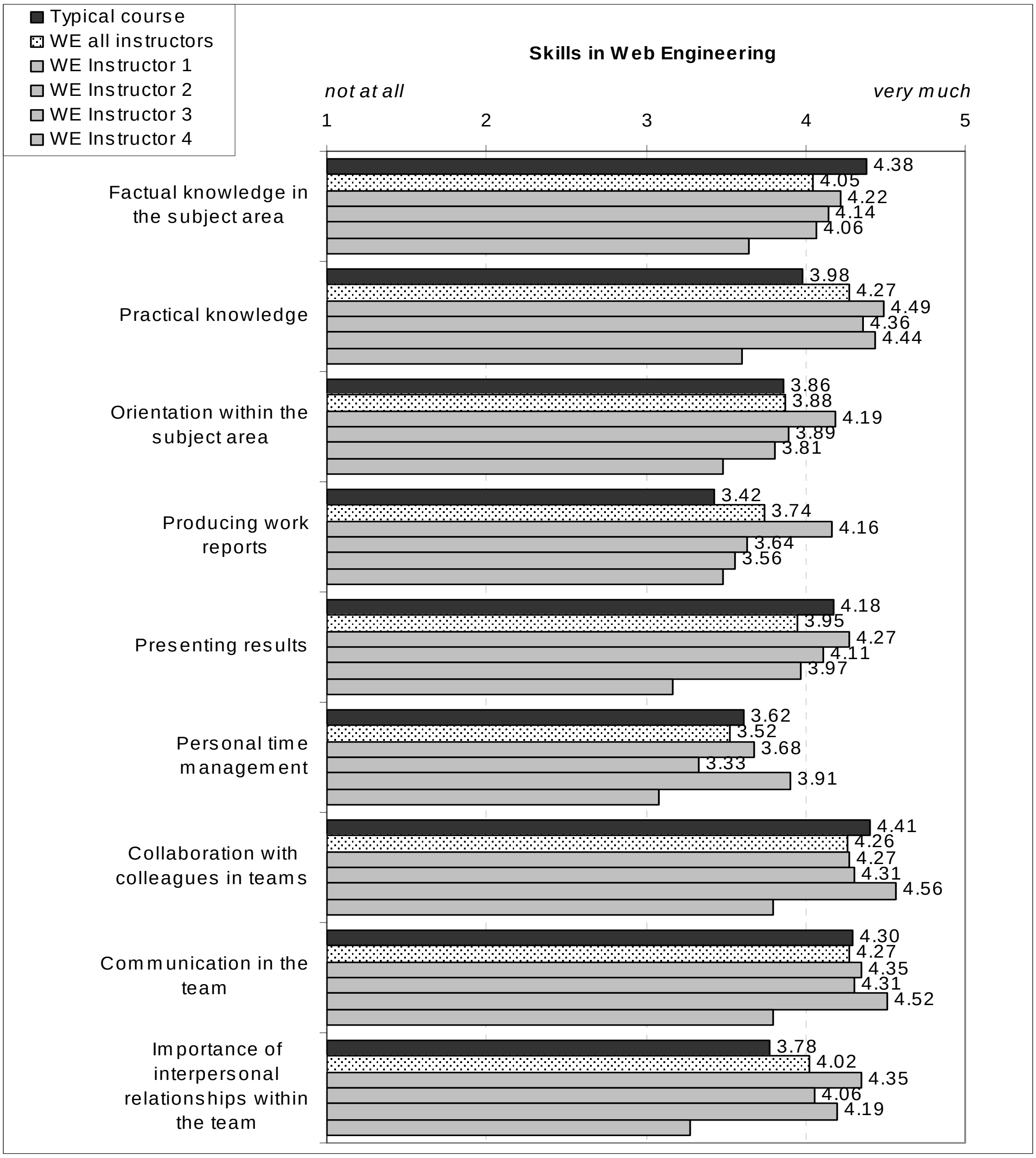

Figure 9. Selected items and competencies as estimated to be acquired in a typical course compared with Web engineering and dependent on individual instructors in Web engineering

Conclusions and Future Work

In this paper we have shared some experiences, reactions, and evaluations of our concept and practice of integrating Web-based learning technology into a humanistic educational paradigm in order to make learning more meaningful, persistent, and effective. Summarizing, PCeL aims to enrich traditional courses by addressing learners at three levels: intellect, skills, and personality and intuitions. Technology is employed to take over a significant part of knowledge transfer at the level of intellect, thereby providing space for active participation and meaningful interactions both in real and virtual communication. We have observed that the interleaving of "here and now" encounters with computer-mediated communication and action has been perceived as a highly constructive mode of sharing and learning cooperatively from multiple perspectives such that constructive cooperation came about faster than in pure settings with face-to-face or online learning.

But what is the added value of PCeL and where does it come from? Students' reactions as well as the empirical evaluation have indicated that students' most significant motives for participating in PCeL style courses have been the increase of professional competence, the experiencing of a positive atmosphere, the collegial cooperation with peers, and interest in the subject matter. Interestingly, these top motives each address one of the three levels of learning: intellect, skills and feelings, and the differences in mean values of these top motives were statistically not significant. These findings support Rogers' theory of whole-person, or experiential learning that emphasizes the integration of cognitions, intuitions/feelings, and skills, based on the actualization tendency that is directed towards actualizing the whole organism. Our initial, and due to the small sample sizes limited evaluation has nevertheless confirmed that instructors who are perceived as highly real or transparent, respectful, and understanding motivate students more strongly than instructors who are perceived otherwise. From this it appears that if the rich and stimulating environment provided by a sensitive use of New Media is also growth promoting, provided by instructors with high interpersonal values, motives for learning flow into each other and complement one another synergistically. Yet, our study also shows that a blended learning paradigm in which there is room for social and personal processes leads to improved learning only if instructors are perceived as personally well equipped to fill this space. It is remarkable that, if the latter is not the case, such a learning paradigm tends to lead to decreased motivation as well as learning outcome. Although our results should be viewed as initial, based on three courses conducted over a period of 1.5 years, they call for a *co-development of media- and personal competence*, if blended learning shall be effective.

Further research will take several directions. First, we are conceptually modeling some generic PCeL elements – we call them PCeL patterns (Derntl & Motschnig-Pitrik, 2004b) in order to support them with appropriate Web-design elements in an open source environment *CEWebS* (Cooperative Environment Web Services; cf. Derntl & Mangler, 2004; Mangler & Derntl, 2004). These are intended to provide the computerized framework for deep and persistent learning on the one hand and to support and simplify the organization, administration, and evaluation of PCeL courses on the other hand. Second, we continue with case studies and action research on PCeL and, concurrently, improve the test instruments in order to be able to observe the effects of changes. Third, we are in the process of populating a virtual community of persons interested in the Person-Centered Approach in higher education (http://elearn.pri.univie.ac.at/pca) in order to have a medium to share experiences and coordinate research aiming to promote authentic science (Hutterer, 1990). Everybody interested in joining is welcome! Last but most challenging and influential is the field of staff development in the spirit of co-developing media-, personal-, and interpersonal competence in order to facilitate PCeL most effectively.

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Situated Cognition and Communities of Practice: First-Person "Lived Experiences" vs. Third-Person Perspectives

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Abstract

This paper considers the work of Martin Heidegger and its relation to situated cognition. The motivation for the paper springs from the perceived misconception that many educators have on situated cognition by applying situated learning strategies in a dualistic orientation, whereas situated cognition is fundamentally relativist (non-dualistic) in epistemology. Hence, we felt that the foundations of situated cognition have to be revisited. In the paper, we relate Heidegger's work to the resurgence of interest in communities of practice and the notions of identity or learning *to be* (vis-à-vis learning *about*). We then draw implications to situated cognition and the complementary role of descriptions or representations to situated learning.

Keywords

Situated cognition, communities of practice, first-person "lived experiences", third-person perspectives, learning to be

Introduction

In this paper we articulate our reflections on situated cognition which has been around for more than a decade since the late 1980s or early 1990s (Brown, Collins & Duguid, 1989). Since its advent, many researchers and educators have hopped onto the bandwagon of its "new-ness" and as with any proliferation of its use, personal understandings or appropriations of this concept may differ across individuals. Today many educators adopt the terminologies of situated cognition or its related notions such as authenticity, problem-based learning, anchored instruction, situated learning, and others. Returning to the foundations, we reiterate the fundamentally non-dualistic epistemology and relativistic philosophy of situated cognition. However, many educators seem to adopt it in dualistic terms or apply situated cognition strategies in a traditional dualistic orientation. Dualistic thinking connotes an objective interpretation of the world and an attempt to mirror it through mapping objective "interpretations" onto the minds of students. Such a thinking and approach is pervasive in all dimensions of society. Because there is a prevalent view that there is no means to verifying "objectivity", philosophers are arguing for a relativist view where criteria for judging validity is based on common consensus and shared beliefs. This view does not therefore mean that there are no absolute truths about reality; however, it does imply that we cannot get down to a truly objective knowledge based on our human biases, beliefs, and interpretations.

The misunderstanding of dualistic thinking is pervasive and subtle. For example, many attempts are made in today's society to model successful practices at all levels, including modeling the 'Silicon Valleys', 'Harvard's' and 'MIT's' which we know of, and creating similar institutes elsewhere by direct transplantation of these successful models. Countries pour huge investments in financial and infrastructural resources in attempting to simulate or model these successful practices, but fail to realize that the principle of emergence and *in situ* cognition, development, and historicity is missing. The greatest difficulty to our minds of situated cognition is in the implementation. Educators need to understand the fundamental emergence epistemology of situated cognition before they can attempt to implement situated cognition in their respective contexts. Such an epistemology is non-dualistic and the prevalent practice of strictly 'mirroring' or 'transferring' objective knowledge from one individual to another is a contradiction in terms (oxymoron).

In this paper, we reconsider the writings of Martin Heidegger, in particular: "Being and Time" (1962). When situated cognition was initially mooted more than a decade ago (see Winograd & Flores, 1986), Heidegger's (1962) work was seriously considered. From the writings of Heidegger we relate the issues of identity to the notion of communities of practice and the concepts of learning. Finally, we argue for the dialectical role of "lived experiences" (first person experiences) and third-person perspectives in situated cognition and the necessity for a balanced view to learning.

Situated Cognition and Martin Heidegger

Recent works in situated cognition reminds us that learning is an appropriation of "ways of seeing" meaning (or acquiring an interpretive lens)—related to identity formation of the individual within a social community. Identities are shaped through local interactions in which individuals confirm or disconfirm each others' state of identity. In this sense, identity is always mutually constitutive, and re-constituted through local interactions within the community. As knowledge cannot be detached from the knower, it has no independent existence; it is part and parcel of the identity of the individual.

Situated cognition informs us of two tenets. The first is the inextricable interwoven nature of context and cognition (Bredo, 1994). In other words, meanings are perceived as inseparable from interpretation, and knowledge is linked to the relations of which it is a product. The implicit dimensions include epistemological and cultural assumptions underpinning a context. The second tenet which situated cognition offers is the *in situ* nature of cognition -- that is, every thought is a (re)construction, and that the memory we possess is not a 'stored' memory, but a process memory (Clancey, 1997), which in essence denotes the emerging nature of cognition-in-action. Clancey (1997) reminds us that it is impossible to capture the densely interwoven nature of conceptual knowledge completely in explicit, abstract accounts, which he calls descriptions. We basically can say (or make explicit) much less than we understand; and our understanding is much less than the "reality" (Polanyi, 1964).

The situated cognition perspective as advocated does not deal primarily with the relationship between entities as distinct and separate. Instead, it considers the system—context, persons, culture, language, intersubjectivity—as a whole coexisting and jointly defining the construction of meanings. The whole is not composed as separate entities but is a confluence of inseparable factors that depend on one another for their very definition and meaning. According to such a perspective, the mind incorporates person-environment interaction, where activity involves an interaction between person and environment that changes both. In this sense, learning means weaving into the perceived fabric of life as an authentic activity. For Martin Heidegger (1962), existence and interpretation are essentially the same thing, thus making interpretation key to all three aspects of situatedness. Existence is essentially the same as interpretation because human-kind cannot be divorced from interpretation. From a post-modern perspective, all 'realities' are interpretations.

The initial thrust in situated cognition research signals a shift from the study of how we *process representations* to how *representations are created and given meaning*. In other words, representations are used primarily for *communication* rather than for *processing* – our brains processing "if-then-else rules". An essential idea in creating representations and meaning making is that this process is perceptual and inherently dialectic. As representations emerge from the interaction of mental processes with the environment, they are not the stuff of mental processing. Each time we create these representations, we are engaged in an act of perceiving and reconstructing; we are interpreting. Categorizations of things in the world are not retrieved descriptions, but created anew each time. In addition, representations may themselves be interpreted interactively, in successive cycles of perceiving and acting. Instead of an objectivist world view where the aim is to arrive at the one singular "truth," the situated view is a relational perspective where knowing is a social process of continually seeking for explanations of holistic phenomena and yet preserving an awareness of the inadequacy of any unified conclusion.

Theoretical foundations for situated cognition can be provided by the writings of Martin Heidegger, in particular, his emphasis on the non-dualistic nature of mind and body, or the unity of mind and external reality. We discuss the writings of Martin Heidegger with emphasis on his masterwork, "Being and Time". We do know that Heidegger's major work, "Being and Time", was dedicated to Husserl who is associated with phenomenology. Heidegger's thought is complex, and any attempt to convey it in brief fashion must necessarily produce distortion. Confining our discussion to the more general concept of Being, Heidegger begins "Being and Time" with the question of Being, or of what it is "to Be". "To Be" here is similar to the notion of learning *to be* or identity formation (Brown & Duguid, 2000). From Heidegger's perspective, Being cannot be defined because Being is not an entity. In one sense, we could almost render Being as "human being," since it is a way of understanding our human existence, and thus derivatively, of understanding being in general.

Heidegger says that modes of Being must be seen and understood a priori as grounded upon that state of Being which we have called 'Being-in-the-world'. Being-in is not a 'property' which Being sometimes has and sometimes does not have. Being can only be understood in context and in relation with the world. This relationship between Being and World is intertwined, and although Being can be phenomenologically perceived separately from World, Being exists or takes meaning only in relation to the world. In other words, Being is a relationship, a quality of the way we are related to the world. The world here is being understood as our environment, that in which we are found. Being then is a way of being so related to the world that its contents are not merely objects, separate from us with their own independent identities, but objects only in relation to us. Thus, to be situated means to be situated within Being -- within our experience of the world. Situated cognition must be considered as experiential. When we say cognition is situated, we mean that it is situated in the flow of experience that comprises Being.

Brown and Duguid (2000) similarly speak on learning as an identity formation -- distinguishing between learning *about* and learning *to be*. Learning *to be* (or just being) forms the essence of identity. Congruent to situated cognition, the authors argue that communities of practice (as rich situated contexts) are ideal learning environments for learning *to be*, and practice being the effective teacher. Practice, then, shapes and supports learning.

> In learning *to be*, in becoming a member of a community of practice, an individual is developing a social identity. In turn, the identity under development shapes what that person comes to know, how he or she assimilates knowledge and information. So, even when people are *learning about* … the identity they are developing determines what they pay attention to and what they learn. What people learn about, then, is always refracted through who they are and what they are learning *to be*. (Brown & Duguid, 2000, p. 138)

Identities are observed by others or by members of a community through local interactions in which they confirm or disconfirm each others' identities. In this sense, identity is always mutually constitutive or reconstitutive through local interactions within the community of practice.

Communities of Practice

Researchers are advocating a return to communities of practice (CoP) as the *de facto* contexts for situated cognition (for example, see Barab, Squire, & Dueber, 2000). In this sense, the emergence in situated cognition takes a firm stand on the role of communities of practice as situated contexts through which cognition and the context are always co-determined. A community of practice is a sustained social network of individuals who share a common set of core values and knowledge, including a past history, grounded on common practices. As communities are central to the changing and evolving nature of persons acting (situated cognition), we cannot escape the issue of changing phenomena and practice. Similar to Heidegger's thought of "being-in-the-world", Polanyi (1964) observes that the primitive sentiments of sharing values, experiences, and joint activities in the community are *prior* to formal articulation – that is, reflection. By fully participating in a "ritual," the members of a group affirm the community of their existence, and at the same time identify the life of their group with that of antecedent groups, from whom the ritual has descended to them. The assimilation of great systems of articulate lore by novices of various grades is made possible by a *previous act of affiliation*. Hence, identity is formed within the individual but co-constructed with other members of a community. This implies that each community has a set of beliefs, values, and "way of seeing" which characterize the members. An individual will only be able to get access to this set of beliefs, values and "way of seeing" through assimilation as a member of the community.

Many efforts have been made to 'build' communities (in particular, online communities) but many of these efforts fail to recognize the historical and evolving nature of communities. Situated cognition reminds us of the historical and evolving nature of cognition in context-communities. Due to the need to understand phenomena such as the success of CoPs, researchers engage in a third-person observer theoretician's perspective of such instances, and describe in terms of descriptions, patterns, and principles the context and interactions of CoPs. Books and papers are generated as a consequence. A follow up action could well be to initiate or build a CoP elsewhere to mirror or model the success of a described CoP as explicated in a well-known book. The problem with such an approach is that without the *a priori* community-interactions, structures are put in place to "simulate" a CoP. When we try to simulate a CoP, the historical emerging processes are missing.

The interesting recognition of situated cognition methodologies is the increasing emphasis that the descriptions identified of phenomena in context cannot be over-generalized and that transfer of descriptions and principles across contexts needs to be carefully done – or better known as petite generalizations (Stake, 1995). This is due primarily to the importance of emergence, historicity, and growth within any particular context. So, according to the emergence growth principle, Being (Heidegger, 1962) is human emergence, existence, or life. The next principle is in how we can learn from descriptions and patterns laid out by others such as researchers and inform an already existing phenomena or growth. To reiterate, there is nothing wrong with descriptions and narratives of successful practices *per se*, but we need to make sure that there is contextual and *in situ* nature of cognition. Descriptions can serve as patterns or objects to be scaffolded towards. The patterns and descriptions can serve as a dialectical lens for learners and for practitioners to reflect upon their own practices.

Research in situated cognition can more fully account for an intricate balance between the evolving nature of cognition and the role of descriptions and representations. The original thrusts of situated cognition was not on how we process representations (as in the cognitivist paradigm) but on how representations are created and given meaning within an emerging and in-situ context. Narratives and descriptions can be very much a part of the historical nature of cognition from a first-person interpretation of meanings perspective (rather than a third-person perspective). But third-person descriptions can be appropriated by the 'first-persons' within communities as they engaged in the interactions among members. Third-person descriptions are used as artifacts and tools by the 'first-persons'.

Another emphasis of the nature of historicity in situated cognition is the necessity for the social construction of meanings and interpretations by the 'first-persons' themselves. The epistemological basis of a relational and situated view of meanings is where intersubjectivity can be established through negotiation of meanings. Although these constructions may approach very similar positions as established 'truths', the process through which these meanings and interpretations are constructed is the essence – as Heidegger reminds us that existence and interpretations are essentially the same thing. Instead of a dualistic position where meanings are imposed from the 'outside' (third-person's descriptions), interpretations need to be emerging from the 'first-person'. As a result of these first-person constructions, identities are formed within the context of these interpretations. Similarly, Ricoeur (1997, 1998) uses hermeneutics as the process through which readers are transformed by text or descriptions-narratives. He denotes the process as appropriation. Extending this transformation from texts to collective communities, Ricoeur adopts the position of bi-directional appropriation. Bi-directional appropriation transforms both individuals within a collective membership, yet denotes the individual bearings of influence in transforming the collective activities and goals (both individual and collective are transformed).

To Ricoeur, a hermeneutic circle exists between human experience and narration: experience has a pre-narrative quality that can be meaningfully and coherently organized into a story. Ricoeur accepts the distinction of Dilthey that there two mutually exclusive forms of knowledge: explanation in the causal world of facts and laws, and understanding in the human world of intentions and desires (Dilthey, 1976). He maintains that these perspectives of explanation and understanding must be integrated into a general theory of interpretation. The type of knowledge prevalent in the human sciences consists of objective structures and theories that must be explained, while the type of knowledge characteristic prevalent in natural sciences is not crudely objective but has a history and pre-understanding like any other interpretation.

From a situated cognition point of view, the individual's only epistemic contact with the world or anything outside the individual is his/her interpretation (Bopry, 1999). To experience is to interpret meanings via the individual's senses. In essence, situated cognition reminds us that any instructional context designed for learners should be sufficiently broad in order to accommodate learners' own constructions and interpretations. The task for instructional designers is to create learning environments which learners can form interpretations which would be as accurate as possible with norms and established knowledge which are progressive – that today's knowledge is better than yesterday's. The task of the instructional designer is also to facilitate learners' creation of shared worlds which exhibits learners' abilities to interpret meanings congruent to practitioners such as scientists, mathematicians, artists, etcetera. In other words, the task is to scaffold learners towards 'interpretive lens' which would enable them to enter into conversations with experts in the field. Instructional designers have the task of enabling learners to express meanings via representations and descriptions and to guide them in directions which would facilitate future entry into CoPs. Thus, the instructional practices in schools should serve as bridges to CoPs rather than develop practices that are tangent to societal demands as represented by CoPs. Moreover, schools can develop identities and skills of interpretation to be overlapping with identities of practitioners. These skills could include skills in making observations, recognizing patterns, making hypothesis or conjectures, conceptualizing and visualizing, exploiting analogy and metaphor in thinking (abductions), and experimenting and testing which are required for both the sciences and the arts.

Situated cognition also needs to account for persons who enter into different communities – home, work-practice, religious, and others – and yet are able to balance the identities formed within these respective communities. We posit that there are perhaps overlaps in these identity-formations. Heidegger's conceptions of Being are in the context of the world (Heidegger refers to Worldhood) in general – perhaps here the world is larger than communities of practices. Extending the work of CoPs and situated cognition, can there be identities that span the world as a generalized context? In this sense, "being-in-the-world" extends Being beyond specific contexts and that there are identity-general formations which can transcend specific contexts. We conjecture that perhaps these general traits of identity are non-context bound and thus individuals can move from one community to another and yet maintain a balanced identity.

Concomitant with 'organism' metaphor, communities cannot be pre-designed *per se* but largely evolved. In other words, as in our earlier emphasis, all the processes within the community undergo an evolution, albeit gradually. In Ricoeur's (1997, 1998) hermeneutical understanding of learning as transformational, both 'reader'-learner and 'text'-environment are 'transformed'. In this co-transformational process, identities are formed based on the dialectical interaction, and the essence in learning is the 'dialecticism' rather than a 'mirroring' or 'transferring' of something onto another. It may appear from a 'third-person' observer-theoretician's perspective as transfer, but in essence, nothing escapes the 'first-person' *in situ* emergence of meanings or cognition-in-action. It is timely that Heidegger (1962) reminds us that all existence is interpretation from the 'first-person' perspective of any phenomena – texts, environments, people, descriptions, tools, artifacts, representations, even virtual worlds.

"The Map is Not the Territory"--Phenomena, Observations, and Descriptions

Situated cognition makes the distinction between descriptions and the 'reality out there'. Knowledge can be represented, but "knowledge is never in hand" (Newell, 1984). "The map is not the territory" (Korzybski, 1941). The reality is the territory and our minds create maps of the world through our sensory systems and the historical paths they have treaded. These maps are with respect to the frame of reference of the beholder who operates in the world from these maps. Each map is a representation of reality but the map is not the territory. Each person has his or her own versions of reality.

Communication takes place when the persons can develop shared worlds of understanding and make meaning from their conversations. When enough social consensus is reached, we establish norms in established fields of knowledge. Much of teaching is schools is about communicating these established fields of wisdom. However, an over-emphasis on teaching at the "map" level – the level of description results in the learners not having a chance to experience the phenomenon themselves, and thereby not being able to understand nor exploit the knowledge provided at such a description level.

Representations or versions of "maps" (based on interpretations of a known reality or "territory") have a role in learning as it serves to act as a basis to validate learners' own interpretations or created representations of their understanding. In fact, there are also learning experiences that perhaps learners cannot physically experience the phenomena or "territory" because it may be too expensive, dangerous, or non-feasible. "Maps" can in essence form as a tool for reflection of experiences where further knowledge can be derived and implications drawn from practice.

The map has a prominent role in the natural sciences for describing phenomena or abstractions of phenomena. The field of mathematics is lot about different maps of the world, and languages and notations for representing and manipulating these maps. Paradigms in such fields do change, and when they change, there will come about different maps or mapping techniques. When it comes to the human sciences or about achieving inter-subjectivity, we need to be especially wary that one's map is but an interpretation open of appropriation and re-appropriation.

We communicate our maps through various forms of representations, not limited to natural language. An observer will perceive at this level of description. In order for learning to be meaningful, this experiencing needs to be brought down to the observational and phenomenon level (Bopry, 1999). Having experience the phenomenon, the observer should articulate his observations and experience at the description (through representations) level, making explicit his knowledge for her own self-introspection as well as to provide a basis for communicating to develop common understanding. A first-person interpretation for one becomes a third-person perspective for others but there needs to be this dialectical cycle between interpreting and experiencing within the person.

According to Bopry (1999), organisms experience phenomena at the phenomenon level of experience. Observations are made based on interpretations of phenomenon through activities, but these observations are not necessarily isomorphic to the phenomena. According to Polanyi (1964), we can hardly fully articulate what we know. In other words, we know much more than we can tell, and what is in reality is much more than what we can know or understand. Our observations are put versions or instances of actual reality. Beyond the level of observations, we make descriptions, accounts, or representations of observations.

A situated cognition perspective puts the balance back between experiencing, interpreting and communicating. Maps serve as descriptions and abstractions, and are themselves useful. There are domains where not every experience can be easily made or not every territory can be experienced. There are domains where it is not practical for all learners to experience the phenomena. Therefore, maps serve a useful scaffolding role for experiential learning. We recognize that some fields of study for example theoretical physics and mathematics particularly specialize on representations and abstractions. Mathematicians and physicists are particularly interested in “maps” and how such abstractions lead on to other theories which would make advancements in their discipline.

Situated Cognition has in the last decade emphasized on the rich nature of contexts through which learning occurs. Implied in these rich contexts, meaningful “lived experiences” and “third-person observations” (personal and others’ interpretations) can dialectically inform each other. Information and knowledge representations are useful for learning, but doing and “living out” the knowledge sharpens understanding and practice. The scope of all practice is useful knowledge; and the object of knowledge is advancements in practice. Both “maps” (knowledge representations in practice) and “territory” (actual practice and the lived activities within it) serve to enhance personal understanding within the context of the advancements of knowledge in communities of practice.

Schools based on the traditional objectivist epistemology would specialize on “maps”. Textbooks, media, and other forms of representations commonly attempt to objectify knowledge and contain abstract meanings in forms and descriptions. Schools and examinations are organized in relatively efficient ways to bring students into forms of established “maps” with the danger of insufficiently providing students with rich experiences of the “territories”. There is a real need to rethink schooling and how “maps” and “territories” can be dialectically balanced. The relativist epistemology of situated cognition suggests learners to be enculturated in actual contexts such as communities of practice where identities can be formed and learning “to be” as a way of Being (Heidegger, 1962). But such an approach may not always be feasible seeing the large numbers of students. Schooling remains a viable and necessary function in society. What educators need to consider is how schooling can be made to emphasize more on actual “lived experiences” and abstractions as a central means for reflecting of experiences and communicating for understanding. Schools should foster opportunities for learners to experience phenomena by doing; trigger learners to make meaningful observations (as inferred from behaviors and descriptions); and stimulate learners to express in multi-modal and emotive ways by describing through authoring tools, the creative arts, concept maps, etcetera. Importantly, teachers should not “steal” experience from learners by focusing too much on the “maps” *per se* and prescribe the learning activities too rigidly such that there is little room for alternative solutions and creativity.

Implications to Educational Technologies

We can draw implications for the role of educational technologies for learners to experience “being.” If learning happens from experiencing the territory, then opportunities must be provided to simulate such experiences. Educational technologies can be used to try to re-create or simulate experiences in rich context, providing a simulated “lived experience” for the users. This can range from low fidelity environments such as communicative technologies which connect learners together to form communities of learners, and beyond that, communities of practitioners. Learners “live” in the kinds of situations discussing the kinds of issues which practitioners care about. For a while, the Internet has supported the emergence of such communities. Interactions through prevalent technologies such as hand phones and portable devices have become interwoven into the daily lives of practitioners. These technologies are suitable for promoting intersubjectivity in Dilthey’s realm of the subjects.

Examples of high fidelity environments (where “lived” experiences are made more real) are the kind of immersive environments where users interact in virtual space with various kinds of haptic authenticity. We have seen educational experiments of these kinds on a small or moderate scale, but they have not taken off in a significant way for various reasons not excluding issues about cost and access, and the immaturity of these technologies for scaling up. Immersive environments such as these in which the learner immerses herself and manipulates objects in the world seem suit for understanding Dilthey’s realm of the object such as for the natural sciences.

Rich practices out there have to be captured in their fullness using video technologies – to record descriptions which learners can “steal” from. Tools can be provided for learners to make sense of their interpretations and achieve common consensus, and to articulate these understandings for further interpretations and building upon.

Tools can be used to create different views or abstractions of phenomena which make the concepts and skills clearer to the learner. Technologies can be used to allow learners to articulate their understanding of descriptions by annotating *in situ* visual and timeline-based representations.

Educational technologies can also be appropriated to facilitate opportunities for learners to reconstruct, articulate, or express meanings at the level of descriptions. When meanings are articulated or made overt through multi-modal forms of expressions, these constructions can be brought into the open for individual and social reflection and knowledge is built upon by others. Opportunities for learners to articulate these meanings would be a process in which shared worlds of meanings can be established. Technologies for helping learners express meanings can be at the cognitive, emotive, and social levels of meaning articulation and description. We are more familiar with cognitive and social expressions through environments such as concept-maps and mind-mapping tools, and Computer-Supported Collaborative Learning (CSCL) environments; however more recently, there are tools which help learners express emotions and design-aesthetics through artifacts.

Learners can be assisted to draw implications from their learning experiences at the observations level. These observations can be one's own constructions or descriptions of phenomena or experiences or observations at the social level – others' descriptions, accounts, and articulations. Accounts describing successful stories, patterns, theories, and principles are important for learners to reflect upon. These observational tools include reflection logs, concept-mapping tools, discussion forums, and visualization mechanisms to express data and information, and others. From these observations, learners can also be assisted to draw implications such as issues related to the observations as applied to particular contexts. These implications are again articulated and described for further reflection by oneself or by other individuals. Educational technology can also be designed here to assist the learner(s) to organize observations, logs, resources, and other artifacts to aid in the thinking and discussions.

The current software tools that support concept-mapping and map-making emphasizes relational links which engage a higher level of abstraction. More can be done to support more idiosyncratic links such linking beyond or outside the map to other maps and resources, recommending relevant and possible links, and improving their usability. The vision of the Semantic Web (see http://www.w3.org/2001/sw/) is full of concepts about interlinked worlds with semantic associations facilitating search, retrieval, and access. Research in pedagogical agents has explored the use of such proactive agents to automatically suggest relevant semantic links or similar items of interest to a learner which is trying to make sense of maps. Technologies like XML promote the inter-operability of maps developed by different people at different places.

Ultimately every experience of the learner is an interpreted experience – interpreted either from himself-herself or from another-self. The self interprets the experience from accounts of the past in a reflective-dialectical fashion in order for learning to occur. Educational technology can assist and mediate these processes of interpretation of both experiences and accounts-maps. What we hope that the learner would achieve is increasingly accurate and progressive understandings and interpretations based on established reasoning and rationality derived from communities (CoPs) which have "survived" through their networks of knowledge and beliefs.

Conclusion

In essence, learning *about* is learning the "maps" or from the descriptions and representations articulated by persons and found in books and artifacts, while learning *to be* is about acquiring the dispositions and identity to see and interpret meaning. Learning *to be* is thus congruent to the "territory" (based on our metaphor) where practitioners are able see to the criss-crosses in the landscape and develop expert understandings of the terrain. It is the personal knowledge which one has acquired by having lived in a city or "territory" – the alleys, the rush hour traffic, the pubs, the interesting spots, the parks where one has personally enjoyed or disliked, etcetera. These are the lived experiences which cannot just be described in an account or representation of a "map". Any particular representation or map signifies one particular interpretation or version of a reality. We need to be aware that any representation denotes a certain version of reality and other non-explicit perspectives exist. Finally, both lived experiences (first person) and descriptions made by personal and others' observations (third person) can be appropriated in order to account for a balanced view of situated learning. Both "map" (texts) can be hermeneutically interpreted along with "territories" (lived experiences) in a dialectical manner that transforms both. In other words, we have argued for a balance between learning *about* and learning *to be*. We hope that this paper has been able to rekindle interest in situated cognition where the role of representations and cognition complement each other.

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Sugar, W., Crawley, F., & Fine, B. (2004). Examining teachers' decisions to adopt new technology. *Educational Technology and Society*, 7 (4), 201-213.

Examining teachers' decisions to adopt new technology

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Abstract
This study examined teachers' beliefs about technology adoption as a reasoned, deliberate, intentional decision-making process, as reflected in Ajzen's (1985) Theory of Planned Behavior. Qualitative and quantitative data were collected from teachers in four schools located in the southeastern region of the United States. Overall results indicated that technology adoption decisions were influenced by teachers' individual attitudes towards technology adoption, which were formed from specific underlying personal beliefs about the consequences of adoption. External support from key persons and contextual resources (e.g., funding) were insignificant factors affecting teachers' technology adoption decisions. From these results, we recommend that school administrators work closely with teachers to address their beliefs and concerns about technology adoption and provide an influential level of personal support and resources. We also offer recommendations for educational software designers for developing future technology resources for teachers.

Keywords
Teachers' beliefs, Technology adoption, In-service teachers, Educational technology

> "Design should make use of the natural properties of people and of the world: it should exploit natural relationships and natural constraints." (Norman, 2002, p. 188)

Introduction

In his seminal work, *The Design of Everyday Things,* Don Norman (2002) urged readers to adopt a human-centered design perspective. This viewpoint is a "philosophy based on the needs and interests of the user, with an emphasis on making products usable and understandable" (p. 188). As teacher educators we are firm believers in this design approach. When developing effective and appropriate educational technologies it is critical for developers to anticipate and address teachers' technology needs. Comprehensive technology adoption and integration can be an overwhelming task for most public schools and teachers. The "Field of Dreams" syndrome ('build it and they will come") is too often applied in educational settings without success. In 1999, 99% of all public school teachers reported having computers available in their schools and 84% of those teachers had access in their actual classrooms (U.S. Department of Education, 2000). As of 2002, 92% of the public schools now have Internet access in the classroom, computer labs and media centers (U.S. Department of Education, 2003).

However, only a third of these teachers reported being "well prepared" or "very well prepared" to use computers for classroom instruction (U. S. Department of Education, 2000). The critical variable in this adoption process and subsequent integration is the teacher. Teachers must be convinced of the feasibility of using a particular technology before adoption and integration occur (Office of Technology Assessment, 1995, p. 71).

Existing studies on teachers' technology beliefs

Though funding, equipment, lack of time, and knowledge are known obstacles to successful technology integration (Hardy, 1998; Lam, 2000; Simonsen & Dick, 1997), a critical component in meeting teachers' technology needs is responding to teachers' beliefs toward technologies. In fact, teachers' beliefs are essential in considering how a teacher teaches, thinks, and learns (Richardson, 1996). Hope (1997) wrote, "Teachers basically had to contend with two factors [with technology adoption]: (a) the psychological effect of change and (b) learning to use microcomputer technology." (p. 158). Understanding teachers' beliefs toward technology plays an essential role in successful technology adoption.

Previous studies employed a variety of methods and perspectives to assess in-service teachers' technology beliefs. These methods included: Likert-scale questionnaires (e.g., Ross, Hogaboam-Gray, & Hannay, 1999); case study methodology (e.g., Ertmer, Gopalakrishnan, & Ross, 2001); Concerns-based Adoption model (e.g., Germann & Sasse, 1997; Hope, 1997); in-depth interviews (e.g., Simonsen & Dick, 1997), as well other methods. Several of these technology studies reported that teachers who received laptop computers increased their technology confidence and skills and were more likely to remain in teaching (Falba, Grove, Anderson, & Putney, 2001). Germann and Sasse (1997) found that teachers who participated in a two-year technology integration program improved their technology self-efficacy and their interest in learning more about how technology could impact the curriculum. Ross, Hogaboam-Gray, and Hannay (1999) reported that access to technologies increased teachers' "opportunities for successful teaching experiences, thereby contributing to greater confidence in their instructional ability" (p. 87). In addition, they also noted, "teachers who interpret their interactions with computers as indicative of high ability grow in self-confidence, regardless of their experience" (p. 93). Research reveals also that before teachers use technology for instruction they must be personally convinced of its benefits and must see the utility of using a particular technology (Lam, 2000).

Before technology is used in the classroom teachers focus attention on their students. They want to know what impact it will have on students' learning outcomes (e.g., Higgins & Moseley, 2001). Teachers use technology because it motivates students and offers a different mode of presentation. Instead of using computers for drill and practice, more confident teachers use technology as an instructional tool to enhance students' learning (Lam, 2000). Successful technology adoption in teachers' classrooms is dependent upon school administrators providing an individualized, differentiated process of training and implementation (Gray, 2001). Glenn (1997) commented, "often districts rely upon a 'one size fits all' approach that meets the needs of only a few participants" (p. 126). Teachers must see how technology fits within their localized classroom setting (Stein, Smith, & Silver, 1999).

Teachers' technology beliefs are influenced by their teaching philosophy. Resistance to adopting new technologies stem from teachers' existing teaching beliefs (Norton, McRobbie, & Cooper, 2000). For technology adoption to be successful teachers must be willing to change their role in the classroom (Hardy, 1998). When technology is used as a tool, the teacher becomes a facilitator and students take on a proactive role in learning. Niederhauser and Stoddart (2001) noted a "consistent relationship between teachers' perspectives about the instructional uses of computers and the types of software they used with their students" (p. 27). Often, this change of teaching philosophy and methods focuses on learner-centered teaching and constructivist teaching practices (e.g., Rakes, Flowers, Casey, & Santana, 1999). In fact, Ertmer, Gopalakrishnan, and Ross (2001) found that exemplary technology-using teachers exhibit more constructivist teaching practices. Successful integration of technology into teaching depends on transforming teachers' belief and philosophy concurrently (Windschitl & Sahl, 2002).

Technology adoption as intentional behavior

In this study we sought to examine technology adoption through the systematic application of a comprehensive, causal social-cognitive model of human behavior, developed nearly three decades ago. Introduced in 1975 by Fishbein and Ajzen, the theory of reasoned action (TRA) offered a theoretical perspective that human behavior is intentional and that an individual's stated intention to engage in a behavior is the most immediate predictor of that behavior. Behavioral intention was posited to mediate the effects of two social cognitive variables, attitude toward the behavior and subjective norm. Attitude toward a behavior reflects an individual's personal disposition toward engaging in the behavior and represents the individual's assessment of the personal beliefs regarding the target behavior's effectiveness in producing favorable and unfavorable outcomes, each outcome weighted by a personal evaluation of the outcome. The normative component, subjective norm, represents a person's perception of whether significant others support engaging in the behavior weighted by the person's motivation to comply with the perceived wish of the significant others. Underlying the TRA model is the assumption that the behavior of interest is volitional, completely under the individual's control.

In 1985, Ajzen extended the TRA to allow for prediction of behavioral intention and thus behavior in situations in which an individual has incomplete control. A third, construct was introduced independent of attitude and subject norm, perceived behavioral control, and the resultant model was called the theory of planned behavior (TPB). Perceived behavioral control reflects the belief that an individual holds about the availability of resources and opportunities (factors that further or hinder performance of the behavior). In combination, attitude toward the behavior (AB), subjective norm (SN), and perceived behavioral control (PBC) contribute differentially to the formation of behavioral intention (BI), which is assumed to be the antecedent of behavior (B), as summarized in the following equation:

$$B \sim BI = w_1AB + w_2SN + w_3PBC$$

Salient beliefs form the indirect, underlying cognitive basis of the personal (AB), normative (SN), and control (PBC) antecedents of behavioral intention. The foundation of personal attitude (AB) lies in the salient personal beliefs (b_i) held by an individual about the outcomes of engaging in a behavior, each belief weighted by the extent to which the person values the outcome (e_i). Likewise, the foundation of subjective norm resides in the salient normative beliefs (behavioral expectations of salient referents, nb_j), each weighted by an individual's motivation to comply (mc_j) with the salient referent. In turn, each control belief (the likelihood that each control factor will be present, c_k) is weighted by the power of the control (perception of the extent to which the control impedes or facilitates behavior performance, p_k) to form the indirect measure of perceived behavioral control. The relative contribution of each of the salient personal, normative, and control beliefs to the formation of AB, SN, and PBC, respectively, is described by the expectancy-value theory. According to this theory the value of an attribute (viz., an outcome, referent, or control) is weighted by expectancy that the attribute is associated with performing a behavior (viz., outcome evaluation, motivation to comply, or control power). Links between direct and indirect, belief-based measures of attitude toward the behavior (AB), subjective norm (SN), and perceived behavioral control (PBC) are described respectively as follows and also illustrated in Figure 1:

$$AB = \Sigma_i b_i e_i \qquad SN = \Sigma_j (nb)_j (mc)_j \; PBC = \Sigma_k c_k p_k$$

We chose to view teachers as reflective, rational practitioners whose technology adoption decisions result from thoughtfully considering the consequences, social support, and resources available to them. The Theory of Planned Behavior offered a useful framework for viewing technology adoption as a change in teachers' everyday instructional behaviors in the practical, real-world context of classrooms and schools today.

Goal of study

Our study sought to identify and examine teachers' beliefs regarding their decision to adopt new technology into their classrooms using Ajzen's (1985) Theory of Planned Behavior (TPB). We originally focused our efforts on a high school and then expanded our study to include three additional K-12 schools located in the southeastern region of the United States. These schools included an elementary school, middle school and a private school (K-8).

Methods

Pre-assessment survey

We initially examined the current technology beliefs of six teachers in the high school. To select these teachers, we applied Patton's (2002) purposeful sampling procedures guided by results of a pre-assessment survey. This survey revealed faculty's technology skills and beliefs toward technology use at this high school. We selected a heterogeneous, representative group of teachers from the faculty. To achieve this representation, we selected teachers based upon the following five factors, namely, content area, technology experience, gender, student technology usage and opinion about the school's technology utilization (See Table 1).

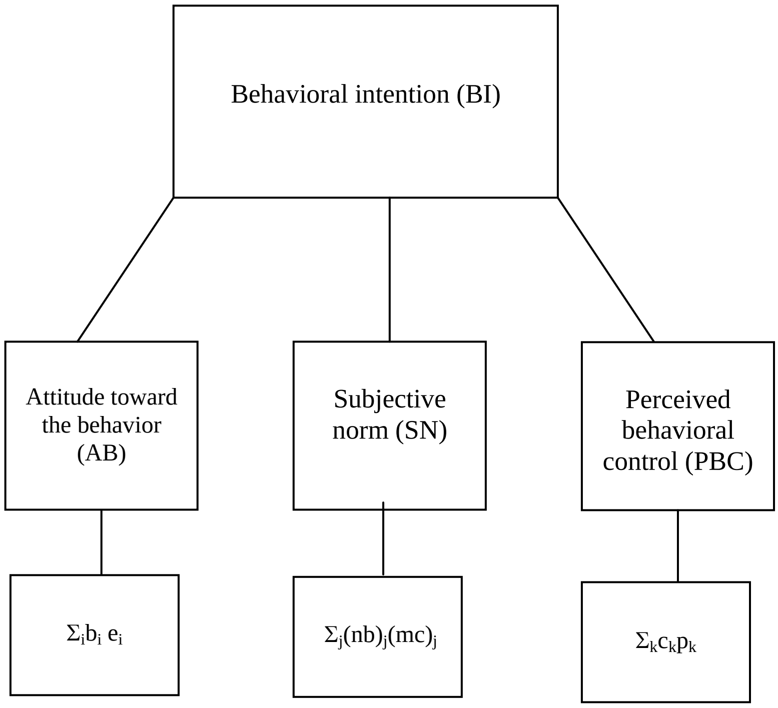

Figure 1: Causal relations among Theory of Planned Behavior variables

Table 1. Selected teachers' pre-assessment responses

Teacher	Gender	Technology skills	How often do your students use technology in your classroom?	Is technology effectively utilized at your school?
Business Education	Female	E-mail; Internet; PowerPoint; computer graphics	Daily	Undecided
English	Female	E-mail; Internet	Monthly	Undecided
Exceptional Children	Male	Basic computer operations	Monthly	Disagree
Math	Female	Internet; PowerPoint; computer graphics	Daily	Undecided
Science	Male	Basic computer operations	Weekly	Disagree
Social Studies	Male	E-mail; Internet	Weekly	Disagree

Open-ended questionnaires and semi-structured interviews

The six teachers representing the social studies, math, science, English, business and special education departments participated in the interviews. We interviewed teachers regarding their beliefs about adopting technology in their classroom. To prompt a discussion of this topic, the teachers answered an open-ended questionnaire, constructed according to the guidelines originally proposed by Ajzen and Fishbein (1980) and described in Crawley and Koballa (1994). Our targeted behavior was "adopting at least one new technology into a lesson by the end of the next school year." Questionnaire items were written to elicit teachers' personal, normative, and control beliefs about technology adoption. After completing this written open-ended questionnaire, each teacher participated in a semi-structured interview. The purpose of this interview was to further explore teachers' answers and gain additional insights. Results from these questionnaires and interviews were transcribed. We use an adaptation of the constant comparison technique (Lincoln & Guba, 1985) to examine the open-ended questionnaire and semi-structured interview data collected in this study. We examined and grouped belief statements according to the three TPB constructs and identified the beliefs believed to be salient to teachers' decision to adopt new technology. Salient beliefs were those that accounted for 75% of the beliefs provided by teachers who completed the open-ended questionnaire.

Closed-ended questionnaire

Salient beliefs were used to develop a closed-ended questionnaire. Teachers indicated their perceptions of the relative influence on behavior (technology adoption) of the personal, normative, and control constructs. The closed-questionnaire provided data from participating teachers regarding the direct and indirect influences of AB, SN, and PBC on their behavioral intention (BI), i.e., their motivation to adopt new technology. Additional information regarding questionnaire construction, data collection and analysis, and model testing can be found elsewhere (see Ajzen, 1985; Ajzen, 2002; Ajzen & Fishbein, 1980; Crawley & Koballa, 1994; Fishbein & Ajzen, 1975, for details). When we had identified which TPB constructs (AB, SN, and PBC) influenced teachers' behavior intention (BI), we then examined the correlations between direct and indirect measures of the constructs (i.e., $\Sigma_i b_i e_i$, $\Sigma_j (nb)_j (mc)_j$, & $\Sigma_k c_k p_k$, respectively) for significance, which then enabled us to specify the personal, normative, and control beliefs that influenced teachers' intentions to adopt new technology. These closed-ended questionnaires originally were distributed to the entire faculty (37 teachers) at the high school. Thirty questionnaires were completed and returned, for an 81% return rate. A total of seventy-eight questionnaires were distributed to teachers in an elementary school, a middle school and a private school. Sixty-seven of these questionnaires were completed and returned, for an 86% return rate.

Results

In the following sections, we describe results from the open-ended questionnaires, semi-structured interviews, and closed-end questionnaires. For the open-ended questionnaires and the semi-structured interviews, we organized the results according to the TPB components.

Personal component

Almost all of the teachers who participated in the semi-structured interviews noted that the sole beneficiaries of adopting new technology in their classroom would be their students. Our respondents identified five salient beliefs representative of their perceptions about the consequences, favorable and unfavorable, of adopting a new technology. These beliefs included:

- • Preparing students for their future careers
- • Exposing students to a variety of new technologies
- • Holding students' interest
- • Enabling students to gain additional skills
- • Making students too dependent on technology

The Social Studies teacher described why it was important to provide technology skills to students. He stated:

> I think the more you introduce these things to high school students—even if it's not in depth but so that they feel comfortable, they can get on the computer, they can start up Netscape, they can check their e-mail, even something as simple as that—might be something that somewhere on down the line somebody says well to do this job we will need you to check in and to check this to see if you have any messages once or twice a day and [they will] ask a student do you know how to work e-mail and they can say yes. That would put them ahead of somebody who has to say no.

He also observed high school graduates working in an employment office who did not "know what in the world they're doing" with the employment office computers. He realized that "some of our students are going to be in there looking for jobs sometimes quite often" and they will need to know how to run basic computer operations. These teachers feel obligated to teach their students how to use technology that might need in their future careers.

In addition to preparing students for the future, adopting a new technology would hold students' interest in their respective classrooms. The Social Studies teacher developed computer games that emulated *Jeopardy* and

Wheel of Fortune. His students played these games to help them review specific social studies concepts and prepare for exams. The Social Studies teacher "could see a great deal of retention even though they thought [students] were just playing a game."

Although all of the interview participants agreed that adopting a new technology would hold students' interest in their respective classrooms, there appeared to be an implicit tension with this assertion. This inconsistency points to a conflict in teachers' willingness to adopt a new technology. In discussing the potential advantage of adopting a new technology, the Exceptional Children's teacher commented, "For the most part, the kids use the computers [for recreational purposes] and they do some e-mail kind of things, and they do searches of their areas of interest, which might be good." He admitted that he found "that computers can be very distracting and sometimes they'll [his students] rush through their work to get to use the computer." The Business teacher also observed that her students always would want to try a new technology as opposed to using an existing one. She noted that "they feel like, or they seem to, that their attitude is well we have done this before why do I have to do the same thing again."

There appeared to be a belief among the selected teachers that students prefer to focus on the technology rather than the content of a lesson. This is exemplified with the Science teacher's short answer response to the question, "what are the advantages to adopting a new technology…." He wrote: "technology engages students, *but* [emphasis added]…only for 'ten minutes.'" During the follow-up interview, he explained his response. He commented:

> It's sort of like that it's something new, boom, and then zoom, okay so it is somewhere else. You know it is like if you get them started on something, it's like then they've got to keep having more and more and more you know. It just seems like that it just doesn't hold their interest very long you know.

In addition to students' expectation for new technology, students also expected teachers to use technology to entertain them. The Social Studies teacher explained this expectation. He remarked:

> I've been teaching long enough to know that you can be swinging in through the windows crashing like James Bond or something like that and ten minutes later the kids will talk about how boring your class is. In five minutes after you're done with that presentation they would have-you know, then they're back to actually having to do class work and suddenly they're bored again. The class is just horrible and we never do anything fun in here.

According to the Social Sciences teacher, this *entertainment* expectation is due to the advent of video games. Students expect to be entertained and if they are not, "they [students] tend to put the blame on the teacher because they're not dancing in front of the classroom or something." Apparently, these teachers equate adopting and using new technologies with increasing students' skills and maintaining their students' interest, but at the same time, adopting a new technology appears to be a superficial solution to helping students learn. The Social Studies teacher observed:

> They [students] do pay attention more to it [technology]. In terms of actually learning how to use the technology if it's just new and exciting, I don't think they really learn the technology that well. I think the more they use the technology themselves then they have to be responsible for presenting some kind of educational material, I think that kind of takes away from the novelty of it a little bit, and I think that gets them a little bit more able to get the point of it rather than the we get to play computers today.

Another negative aspect of adopting a new technology is that students become too dependent on it. Both the Math and Science teachers stated that students' use of technology has become mechanical and they no longer are able to think. The Science teacher defended this assertion:

> My heartburn is kids can't do anything without technology. They can't add. I found out that if I say what is a 1000 divided by 10. They can't do it. They have to get out a calculator and take a thousand and divide it by ten. They can't move decimal points, and I've got Physics kids who can't do math problems without a calculator. They have no idea how to do it. It is just that they do not have to think anymore, and it is very aggravating.

The Math teacher concurred by stating, "I'm finding a lot of kids who don't know the multiplication, because they have had the calculator all along." Apparently, there is a "dark side" to adopting a new technology.

Though a majority of teachers may have a positive attitude towards adopting a new technology, technology usage may be equated with *entertaining* students as opposed to *educating* students.

Normative component

Five salient referents or key individuals related to teachers' decision to adopt a new technology was identified. These included the following individuals: school administrators; principals; parents; employers; and students. Another common response among the interview respondents was all-inclusive. When asked about the groups or people who would approve of their adopting a new technology, several respondents responded, "Everyone". Conversely, when asked about the groups or people who would disapprove of adopting a new technology, a majority of the respondents commented, "No one". The English teacher replied that there is *no one* who would disapprove of using technology. The Social Studies teacher noted:

> If you talk to somebody in administration, county office whoever, you say I'm going to be including more technology in my classroom this year [and they say,] 'oh, great fantastic.' I can't picture anybody telling me that they think it's wrong to teach [using new] technology in a classroom.

The Science teacher concurred by stating: "I don't think anybody would really have any heartache about using new technology."

While "everyone" would approve of a teacher adopting a new technology and "no one" would disapprove, this social support has not been explicitly communicated to teachers by any specific individual(s). For example, the English teacher remarked "no one ever said anything to me personally about the use of technology. It is an indirect expectation or assumption to use it, as we have access to it here." The Exceptional Children's teacher speculated on the administration's intentions. He commented:

> With the administration, I think the concern is more of management. If it had demonstrated effect on managing the classes, I think they would be approving it. I really don't have it clear in my mind to what extend technological prowess is involved in this next year plan.

When asked about whether the school administration supported technology integration, the Science teacher answered:

> You know they're into the technology. The kids have to take a computer class, competency test to pass, have to do this to pass you know so you know they want you to do all this extra stuff but [administrators] give you no money to do it.

The Math teacher stated that "we are encouraged as teachers to take technology courses" but she also noted that it is difficult to obtain additional funding. These teachers perceive that they should adopt new technologies, but there is not a consistent, overt message that directed this activity.

Contextual component

Teachers who participated in the interviews identified five salient contextual referents including: training; time; money; standardized testing; and homogeneous grouping of students. The Social Studies teacher noted that "to expect students who have had no computers in their classroom and a couple in the library that they have access to, to expect them to come in here and be able to use all this new technology is kind of unreasonable." It also would be unreasonable for teachers, who previously had little or no technology equipment in their classroom to expect them to teach without any training. The English teacher lacked knowledge on how to use new technologies and cited "lack of knowledge" as the biggest impediment to adopting new technologies. However, Business Education and Social Studies teachers acknowledged that they took the initiative and taught themselves specific technology skills (e.g., FrontPage). The Math teacher commented "schools have a disadvantage in the area of money for our training in the use of technology." Schools typically will pay for the equipment, but not for training.

Both standardized testing and homogeneous grouping limit teachers' use of technology in their classroom. Though standardized testing and grouping of students seem unrelated to teachers' ability to adopt a new technology, these practices do limit teachers' ability to teach in their classroom and thus, have an indirect effect on technology adoption. At the respondents' school, teachers are expected to structure their curriculum according to the end-of-grade or end-of-course exam. Since one-fourth of the students' final grade is based upon results of the statewide exam, teachers are told to emphasize multiple-choice questions in their class. The Social Studies teacher reported:

> [Teachers] have been told to incorporate multiple-choice questions because that's what kids are going to see on the end-of-course test. It doesn't make any difference whether or not it's a better way to teach them that they get better understanding of the subject matter. That's irrelevant. What is relevant with the way things are now is to show it on the test.

The emphasis on multiple-choice questions limits the types of technologies that teachers can adopt. Consequently, they only utilize technologies that facilitate multiple-choice test taking.

The heterogeneous grouping of students also limited the choice of technologies to adopt in the classroom. The Science teacher would prefer homogeneous grouping and fewer students in his classroom. He remarked:

> I have classes with three students it. I have done more things with those classes than I would ever think about doing with a class with thirty people because if I am looking over here, then I have people here doing things, and I have no idea. I had one [student] who picked up a glass beaker and drank its contents. He had no idea what was in it, but he drank it and luckily it was only colored water. Do I cater to this kid down here and this kid and hopefully I can give him something that will keep his mind occupied and then I have got everybody else in the middle. Who do I teach to? It is hard to teach to all of them. If I had a class that was exceptional then, I could teach at one level. If I had a class of regular students whatever they are, I could teach another level.

When asked what he does to remedy this particular situation, he responded:

> I basically have the same activities. I end up expecting less from the lower students. It is very hard. Not only do you have the ones that are low on intelligence but you have the behavioral ones in here too. You are trying to fight keeping them quiet to keep the rest of them in their seats or whatever, and it is just such a large discrepancy between the different stuff and the lower. About a fourth of our kids are on the lower level, but they just mix them all together.

This limitation on teachers' ability to instruct to a particular group of students reduces teachers' choice of available technologies to adopt and utilize in their classroom.

Closed-end questionnaire results

Results of the closed-ended questionnaire analyses are promising. We found that 68% of the respondents adopted at least one technology during the past year and results of the data analyses also reveal that over two-thirds of the teachers held favorable beliefs toward adopting a new technology in the upcoming year. The new technologies included: software applications, online tutorials, web page development, Kurzweil 3000, graphing calculators, and other similar instructional technologies. Overall, respondents were quite likely to adopt a new technology during the next school year (M=1.8; SD=1.245). Teachers' motivation to comply factor (M=1.35; SD=2.984) and the external factor (M=3.96; SD=3.506) were moderate (see descriptive closed-end questionnaire results, direct, and indirect measures of the TPB components in Table 2).

We examined the independent contributions of the three direct measures of the TPB model variables, namely the personal, normative, and contextual components to the prediction of Behavioral Intention (see Table 3). In the aggregate, the personal component, Attitude toward the Behavior, was the best predictor of teachers' intention to adopt a new technology during the next year ($ß=.619$; $t=6.337$; $p<.01$). Then, we disaggregated the group data so that we might examine these relationships for different teacher subgroups, according to the following characteristics:

- Types of schools (High; Middle; Elementary; and Private)
- Teaching experience (1-5 years; 6-20 years; and 20+ years)
- Number of workshops completed during the past five years (1-2 workshops; 3-5 workshops and 6 or more workshops)
- Adoption of new technology during the previous year.

Examination of the disaggregated data revealed that attitude was the lone predictor of intention to adopt a new technology but only among public high school teachers (ß=.772; t=6.647; p<.01), not teachers in middle or elementary schools. Among private school teachers, the personal (ß=.543; t=2.856; p<.01) and normative (ß=.342; t=2.470; p<.01) components were found to be predictive of their intention to adopt new technologies.

Table 2. Descriptive closed-end questionnaire results

Item	M	SD	Actual range	Possible range
Intention (BI)	1.8	1.245	-2 to 3	-3 to 3
Personal component (AB)	8.01	3.35	-3 to 12	-12 to +12
Personal component indirect measures				
Students – Future careers	5.58	3.24	-6 to 9	-9 to 9
Students – New technologies	5.38	2.96	-6 to 9	-9 to 9
Students' interest	5.48	2.828	0 to 9	-9 to 9
Students – Additional skills	5.6	2.255	0 to 9	-9 to 9
Students – Too dependent	1.16	3.193	-6 to 9	-9 to 9
Normative component (SN)	1.35	2.984	-6 to 6	-6 to 6
Normative component indirect measures				
School administrators	3.25	3.127	-4 to 9	-9 to 9
Principal	3.2	3.602	-9 to 9	-9 to 9
Parents	2.28	2.883	0 to 9	-9 to 9
Employers	2.78	3.303	-9 to 9	-9 to 9
Students	2.39	3.092	-6 to 9	-9 to 9
Contextual component	3.96	3.506	-6 to 9	-9 to 9
Contextual component indirect measures				
Training	4.74	4.459	-9 to 9	-9 to 9
Time	5.56	4.14	-9 to 9	-9 to 9
Less objectives to teach	4.41	4.436	-9 to 9	-9 to 9
Money	6.02	3.396	0 to 9	-9 to 9
Homogeneous	3.61	4.019	-9 to 9	-9 to 9

Table 3. Regression of TPB Model Variables on Intention (BI)

Category	Item	n	Personal (AB)	Normative (SN)	Contextual (PBC)
All teachers		97	ß=.619; t=6.337**	ß=.05; t=0.604	ß=.034; t=0.354
Schools	High	30	ß=.772; t=6.647**	ß=.032; t=0.308	ß=.153; t=1.326
	Middle	20	ß=.478; t=.1.508	ß=.147; t=0.635	ß=.066; t=0.232
	Elementary	33	ß1.268; t=0.215	ß=.106; t=0.513	ß=-.058; t=-0.250
	Private	14	ß=.543; t=2.856**	ß=.342; t=2.470**	ß=.424; t=2.174
Years teaching	1-5 years	26	ß=.263; t=1.136	ß=.175; t=0.947	ß=.339; t=1.571
	6-20 years	32	ß=.606; t=3.495*	ß=.195; t=1.331	ß=.006; t=0.036
	20+ years	37	ß=.857; t=6.546**	ß=-.122; t=-1.068	ß=-.152; t=-1.161
Workshops	1-2 workshops	24	ß=.352; t=1.477	ß=.16; t=0.826	ß=.185; t=0.776
	3-5 workshops	40	ß=.841; t=7.091**	ß=.114; t=0.954	ß=-.323; t=-2.684**
	6 + workshops	29	ß=.536; t=2.616**	ß=.083; t=0.499	ß=.25; t=1.162
Adopt during past year?	Yes	63	ß=.710; t=5.244**	ß=.055; t=0.518	ß=-2.07; t=-1.556
	No	29	ß=.506; t=3.158**	ß=.075; t=0.484	ß=.306; t=2.023

* Significance at the 0.05 level. ** Significance at the 0.01 level.

Next, we disaggregated the data according to teaching experience. Among experienced teachers (persons with 6-20 years of experience (ß=.606; t=3.495; p<.05) and persons with 20+ years of experience (ß=.857; t=6.546; p<.01), the personal component alone was predictive of teachers' technology adoption intentions. None of the TPB components were predictive of new teachers' (persons with 1-5 years of experience) intentions to adopt new technologies.

We then disaggregated the data according to the number of technology workshops teachers had completed within the past five years and examined the independent contributions of personal, social, and contextual components to the prediction of intention. Among teachers with some technology training (3-5 workshops) (ß=.841; t=7.091; p<.01) and teachers with considerable training (6 or more workshops) (ß=.536; t=2.616; p<.01), attitude toward technology adoption was predictive of their technology intentions, but neither the personal, social, or contextual factors were predictive of the technology intentions of teachers with limited training (1-2 workshops). In addition to the personal component, the contextual (ß=-.323; t=-2.684; p<.01), variable also was found to be predictive of the technology intentions of teachers with some training, but in unanticipated ways. Additional resources and opportunities were predictive of a reduced commitment to technology adoption.

For our final sub-group analysis we disaggregated data into two groups of teachers, individuals who indicated that they had adopted a new technology during the previous school year and those who reported that they had not. Regardless of prior adoption decisions, the personal component was the sole predictor of teachers' intentions to adopt a new technology during the upcoming year [Adopters: ß=.710; t=5.244; p<.01 and Non-adopters: (ß=.506; t=3.158; p<.01)].

Table 4. Correlations between direct measures of model variables and belief-based estimates

Category	Sub-category	n	Personal (AB) (Direct/Indirect)	Normative (SN) (Direct/Indirect)	Contextual (PBC) (Direct/Indirect)
All teachers		97	r=.641; p<.01	na	na
Schools	High	30	r=.632; p<.01	na	na
	Middle	20	na	na	na
	Elementary	33	na	na	na
	Private	14	r=.736; p<.01	r=.781; p<.01	na
Years teaching	1-5 years	26	na	na	na
	6-20 years	32	r=.632; p<.01	na	na
	20+ years	37	r=.654; p<.01	na	na
Workshops	1-2 workshops	24	na	na	na
	3-5 workshops	40	r=.619; p<.01	na	r=.129; p>.05
	6-11 workshops	29	r=.794; p<.01	na	na
Adopt during past year?	Yes	63	r=.661; p<.01	na	na
	No	29	r=.538; p<.01	na	na

We next examined the antecedent beliefs for sub-groups in which significance was found between one or more model variables (personal, normative, and contextual) and behavioral intention (BI). First, we examined the significance between the direct measure of the model variable and its belief-based estimate, for each subgroup. In each case, the belief-based estimates were found to good estimates of the direct measure (see Table 4). We further analyzed the data using regression analyses to identify the significant salient beliefs that contributed to the direct measure of each key model variable. Specific significant beliefs were identified among the subgroups. Preparing students for their future careers (t=3.157; p<.01) and providing additional skills (t=4.913; p<.01) were determined to be significant predictors of teachers' attitude toward technology adoption as a group. For teachers who had adopted new technology during the past year these same two factors, preparing students for their future careers (t=3.649; p<.01) and providing additional skills (t=3.196; p<.01) also proved to be significant beliefs underlying their technology adoption attitudes. Moreover, preparing students for future careers was a significant salient belief for teachers, who took 3-5 technology workshops during the past five years (t=2.554; p<.05), for teachers, who took 6 or more technology workshops during the past five years (t=- 3.552; p<.01), and for teachers, who did not adopt technology during the past year (t=2.881; p<.01). Holding students' interest (t=3.208; p<.01) was found to be a significant salient belief for teachers who had taught between 6 and 20 years. Among teachers with more than 20 years of experience, preparing students for their future careers (t=3.12; p<.01) and making students too dependent on technology (t=2.066; p<.05) were identified as salient beliefs underlying their attitude toward technology adoption. More experienced teachers believe that their students become too dependent upon technology and that technology *entertains* more than it teaches, as corroborated by results of our semi-structured interviews.

Discussion

Primary importance of personal component

One of the key outcomes of the closed-end questionnaire results was the primary emphasis of the personal component on teacher's intent to adopt a new technology. Based on our study's results, technology adoption is a personal decision, uninfluenced by other people and the presence of resources or impediments in the local school/district. The normative and contextual components did not have any significant effect on teachers' motivation to adopt new technology. The fact that technology adoption results solely from teachers' conscious reasoning about the personal consequences for doing so may reflect the isolated nature of the teaching context, a situation in which supportive people, resources, and in-classroom training are lacking and thus viewed as inconsequential to the technology adoption decision. Though teachers' decision focuses on the consequences for students (i.e., future careers and students' interest), the student plays a non-significant role as either a social or contextual influence. The exclusive focus on students interest and career needs indicates a necessary change in how teachers perceive technology adoption. They may lack an understanding how technology can assist their careers as teachers. Training and implementation efforts may need to help teachers understand how adopting new technology helps teachers, in addition to their students. By adding this new message, teachers will have another reason for technology adoption and will avoid the conflict about the *entertaining* aspects of technology.

Enhancing the normative component

The insignificant social or normative factor is disconcerting and reflects the "everyone wants teachers to adopt technology" perspective. Teachers lack a specific, clear message and personal support from school administrators about technology adoption. Besides the politically correct and generic "technology is good" message, teachers need to know how technology will affect their roles and how to effectively use technology in their classroom. We question why school administrators and other key school and district personnel are seen as inconsequential in this technology adoption decision. Critical stakeholders (e.g., administrators) affecting teachers' adoption decisions need to clearly communicate their vision of the benefits of and provide implementation support for adopting new technology in teaching. This communiqué should not be an exclusive directive, but a message that supports and enables teachers to collaborate in ways that *directly* benefit teachers, as well as their students.

Implications for educational software designers

Results from our study offer a mixed message for educational software designers. On the one hand, administrators and school media specialist usually purchase software and other related technology. On the other hand, teachers are sole decision-makers regarding technology use in their classrooms. Consequently, educational technology and software designers must train their adoption efforts to two groups, the buyers and the users of technology. Messages to school administrators about technology adoption might differ considerably from the messages presented to teachers about the personal consequence, social support, and needed resources associated with technology adoption. Because of the apparent gap between teachers and school administrators on specific ways to adopt technology, it is quite difficult to ascertain how to directly affect teachers and their technology needs. To remedy this situation, designers must bridge this gap by working with school administrators and teachers to develop specific, coherent technology adoption messages.

Another factor that designers must consider pertains to unique beliefs held by high school teachers about the consequences of technology adoption in their teaching context. Operating in an environment driven by end-of-course tests and concerns about reaching a diverse group of students in their classrooms (i.e., standardized exams and homogeneous grouping of students) high school teachers struggle as to the best use of new technologies. Middle, elementary and private school teachers apparently do not share high school teachers' unique contextual concerns. It would be prudent for educational software designers to consider the specific contexts and school environments when developing software applications for each group of teachers.

Conclusion, limitations, and future directions

The results from our study provide insight on teachers' beliefs toward technology adoption. These results not only confirm the primary importance of teachers' personal decision-making on whether a new technology is adopted or not, but also indicate an apparent conflict between teachers' technology adoption perspective and that of school administrators. The teachers, who participated in our study, and their corresponding behaviors, limit the generalizability of our results. Future TPB studies that concentrate on a group of teachers from a different geographic region and/or who teach in a different school system may yield an altered set of results. Our study also solely focused on teachers' intention to adopt new technologies. Other factors, such as teachers' confidence and competence in using technology also play a role in this behavior.

Our specific future plans are two-fold. First, we want to collaborate with school administrators to develop specific coherent technology adoption messages and assist in the design of implementation programs for their teachers. We also would like to replicate our study with a different group of teachers, this time examining not only teachers' technology adoption intentions and their personal, social, and contextual beliefs but their teaching philosophy as well and the role that philosophy plays on teachers' technology adoption decisions.

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Malinski, R. (2004). Book review: Virtual Learning and Higher Education (David S. Preston). *Educational Technology & Society*, 7 (4), 215-218.

Virtual Learning and Higher Education

(Book Review)

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Textbook Details:

Virtual Learning and Higher Education
(volume 8 in At the Interface project)
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http://www.rodopi.nl/senj.asp?BookId=ATI%2FPTB+8
Rodopi, Amsterdam Tijnmuiden 7, 046 AK Amsterdam
The Netherlands
ISBN 90-420-1129-7
2004, 182 pages

Introduction

Editions Rodopi has provided a great deal of information about this book on their webpage. Located at the first site noted above there is a brief overview of the book and an indication who might be interested in it. There are also notes on the contributors and abstracts of the ten papers included in this eighth volume in the At the Interface series. For those who would like to scan the backgrounds of the contributors and read abstracts of the papers, the webpage is the place to go.

The following material provides comments on and reactions to the volume in general and the papers specifically rather than repeating what is already available on the webpage.

These papers are from a conference at Mansfield College (Oxford) held in September 2002 with some of the references updated to mid 2003. The ten papers in this volume are divided into three sections. These sections called Frontierland, Into the Unknown, and Looking before Leaping provide an array of practical examples and philosophic insights of value to newcomers wanting a grasp of important issues in virtual learning or the experienced wishing to see what others are doing in the field.

Frontierland

Frontierland, the first section, includes four papers covering the strategic and the tactical. Waring and Boardman start off by describing the development of an eight part virtual learning environment (VLE) framework for the training of physical education (PE) teachers at Durham University. While the parts of the VLE would be familiar to most distance education instructors, the section of the paper on Issues and Challenges is most informative and corroborative. Waring and Boardman begin by pointing to that bugbear poor access both at a technical level and at personal level. Technical access varies from place to place and over time and so the instructor must keep this in mind so as to remain flexible and understanding. On the personal level, Waring and Boardman suggest that there needs to be some anonymous posting capabilities in order to facilitate sharing of and benefiting from experiences that might be infringe on someone's privacy. This flows clearly into the ethical issues faced by instructor and students in a physical education course. In this case, the PE teachers that wish to share experiences and developments from their own schools must gain consent from their students and their parents. Without that they would not be able to share valuable insights from their experiences most of which deal with children. This ethical issue is coming more and more to the fore, as it should, not only in distance education specifically but also in education and in our society generally. Waring and Boardman continue with a comment on the use of PDAs, on the importance of the communication zone of their framework in promoting quality assurance and facilitating research into pedagogy. Finally, they clearly recognize the VLE certainly as challenging to implement but as a worthwhile educational paradigm that engages both student and teacher in their own learning.

Price and Lapham discuss the virtual seminar from several perspectives one of which is that of assessing the views of full-time versus part-time students. They deal with the pros and cons of virtual seminars as opposed to face-to-face seminars in general. This in turn is used as a base from which to describe their study of first-time distance students. They point out, among other things, that students re-entering after a number of years have higher satisfaction with the asynchronous, any-time, any-place mode than the traditional students. They also noted that the non-traditional and the traditional students are somewhat intimidated by each other; the former with the educational experience of the later and the later with the work experience of the former. However, they commented on the ability of both groups to have their voices heard in the communications section of their framework and the importance of the instructor in creating an atmosphere where students feel in control and as a result less intimidated.

The third paper, by Ross and Davis, covers the E-Learning Plan (ELP) of Athabasca University (AU) which is billed as "Canada's Open University." Ross and Davis describe AU's background and the approach to course development, in general, and turn to the ELP more specifically. With this 2001 plan and its revisions AU signaled a move from print to online as their primary delivery mode by 2006. Readers can visit the AU at http://www.athabascau.ca and judge the current state of this move. Ross and Davis outline many of the challenges facing this move, to removing barriers to post-secondary education, and to increasing access for students. They note the need to revamp the course development approach to accommodate online courses; the requisite support structures for instructors and students; the need to develop open-source management systems rather than use of a variety of proprietary software as at present; the transformation of their static print materials to dynamic materials (e-books and streaming audio and video); and the development of an online communication environment that can cope with continuous enrollment and differing rates of student progression. These are weighty challenges all of us who move in and through distance education face.

The last of the papers in this first section describes the development of a web-based resource page to be used by online instructors at the University of Phoenix (UoP). Muirhead introduces some of the challenges facing online instructors, covers the background of the UoP, touches on the importance to UoP of the training of online instructors, and describes the elements (course content and services) of the resource page that UoP courses will contain. This concept of a resource pages is not uncommon in a distance education course, however, Muirhead gives particular insight into the benefits and concerns. Key benefits revolve around bringing some consistency to the courses by providing some structure for instructors as well as easing access by students to content, evaluation, and services while maintaining some local focus. This later issue of local focus is important because the UoP covers many educational districts in the United States and Canada and so must be wary of fulfilling local educational requirements. Concerns he notes are the resistance to using online resources for any length of time, the costs of building such a resource page when there is some doubt as to its effectiveness in promoting relevant interaction, and the amount of time it takes to train instructors to maintain the resource page.

The papers are a snapshot of what was or what might be and as such beg the question, 'What is the status today?' I imagine that we are more or less still in Frontierland because we are still dealing with many of these same issues.

Into the Unknown

Thomson begins the second section by discussing the use of information and communication technologies in workplace learning. He deals with small and medium size enterprises (SMEs) and bemoans the supply side failures of training opportunities in that they are not appropriate in terms of time, cost, or location. It is even more critical in SMEs that learning materials and methodologies be appropriate and not just a repurposing of old materials and ideas! While Thomson does not speak in terms of customer relations management what he says about finding out what the workers need, what the context is that they are in, and what supports they require speaks to a very clear customer/worker perspective. This is a very stimulating paper because it uses well known ideas in fundamental, no nonsense language to set out strategies for improving workplace learning.

Stiles continues with another excellent paper on the implications of a widening participation in higher education (HE). He does so by looking at strategic and pedagogic issues from within a UK focus but which is certainly applicable broadly. Stiles notes that although there is widening participation there are still numerous barriers to student completion (lack of preparedness of HE, changing personal circumstances, financial matters, impact of undertaking paid work, and dissatisfaction with course or institution) that are going unresolved. Similarly with widening participation there is a greater diversity of learning styles but a gap between what is a recognized need and what is actually available in HE institutions. This disconnect results from a number of factors ranging from insufficient staff development in pedagogy or learning activity design; through the pre-occupation with content production to the detriment of pedagogy and learning; to inconsistent or piece-meal institutional strategies towards use of and training in technology. The implications of all these are that many decisions and especially technological ones are being made without clear institutional goals or understanding of long-term impacts. Stiles calls for a national focus to bring aspects of pedagogy, assessment, content, and technology into balance. Not to do so, Stiles notes, would be to the detriment of student learning and staff development as well as achieving national goals and competitiveness. This is sober comment worthy of reading by all education specialists.

Fuller completes this second section by discussing assessment in the virtual learning environment. He recognizes that there are inherent problems with assessment tools but that there is ‘unexploited potential’ available. His example of teaching large classes illustrates how he uses systems to benefit; developing automated marking can save time in large classes. Fuller does not deal with drill-and-kill multiple choice but with the problem of using automated marking with higher order competencies of analysis, synthesis and evaluation. Fuller’s short paper could not cover much detail but takes a positive view that much can be done. He is pragmatic however, by saying that synthesis competencies are outside the realm of automated assessment tools. He does give references to work in the field one of which is to a web site located at the University of Cape Town; http://web.uct.ac.za/projects/cbe/mcqman/mcqcont.html

Looking Before Leaping

The third section of this book consists of three papers that deal with fundamental issues of the university in this age of information and computer technology. Because of this they are immediately more controversial and less able to be encapsulated.

Wood explores the chasm between faculty and administrators and does so using activist language of dissent, conflict, reform and revolution. He calls for laws to protect higher education from administrators who are taking universities down the corporate path. Such laws should limit the number of distance courses acceptable for degrees; protect intellectual property of faculty; ensure substantial numbers of full-time, tenured faculty; strengthen tenure; mandate budget levels; and prevent the corporate takeover or privatization of universities. Whether you accept what Wood says at face value and distance education as disastrous or reject it as outmoded hyperbole and distance education as worthwhile, he does bring up many issues that in part or parcel intrude on our higher education lives.

Bromage puts together a fascinating look, with the catchy title of ‘Atavistic Avatars,’ at the possibility of a truly virtual university. He discusses the nature of virtual reality (VR), brings in some example of its use in schools, delves into how we might develop a sense of being (the ontology of VR), and what it would mean for universities and for students. While he is certainly positive, Bromage is not without his concerns. The major concern is that centering on the importance of establishing VLEs which allow and nurture meaningful student engagement with others on common tasks. This is well worth a read for its array of insights and caveats if not for its Star Trek like qualities.

To finish off the volume, Preston covers a broad swath in his paper on ‘Virtual Values: The University in Crisis.’ Preston explores how technology in general has had a great impact on our society and now information and computer technology is having a significant impact on universities. His study of the National Technological University and comment on the British situation suggests that there are imbalances the broad strategic views and the concerns of the local and national communities. He is not unlike Wood and Bromage in having concerns about unguided or unreasoned use of technology but couches his concerns in calmer and less futuristic terms. Preston notes that universities, and the British nation itself, must take a more holistic approach to technology, its use, and its impacts.

Preston’s paper for all its calmness is the most disturbing of any of the other papers in this volume. The other sections illustrate concrete and practical items while the two other papers in this section give extreme perspectives which may be accepted or rejected with little impact. However, this paper details the insidious nature of what Preston calls ‘the macro-technological issue’ by which he means, ‘an increased alacrity to use technological values to determine the university mission and future.' This is evident, the paper notes, not only in the growth of managerialism with its language of efficiency but also of the closing down of democratic practice, and a rejection of a balanced approach. All of us in HE probably have our own examples that fit this definition and detrimental practices. Preston in this paper would ask, "What are you doing about it?"

Preston offers a remedy. He provides his vision of a university which is 'a place where frameworks for knowledge appraisal are negotiated and agreed through a narrative of tradition.' With this Preston harkens back to the idea of the university but then formulates a vision to fit the 21^{st} century. He gives a goal towards which university communities can work towards in the way that they determine best for themselves.

This volume has many hidden highlights that would be of value to many in the distance education area. It gives practical insights mostly from a British perspective, references to many articles and books, and up-to-date web sites for current research. Most of all it shows the education community that there are groups exploring distance education topics, moving ahead as best they can, and grappling with obstacles successfully. This is a good read because it offers many hours of reflection afterwards.

van Schie, J. (2004). Book review: Relearning to E-learn: Strategies for Electronic Learning and Knowledge (Marcus Bowles). *Educational Technology & Society*, 7 (4), 219-220.

Relearning to E-learn: Strategies for Electronic Learning and Knowledge

(Book Review)

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Textbook Details:

Relearning to E-learn: Strategies for Electronic Learning and Knowledge
Marcus Bowles
http://www.mup.unimelb.edu.au/ebooks/0-522-85130-4/
Melbourne University Press
2004

The book Dr. Marcus Bowles presents is the result of a major research project Learning to e-learn. The research was conducted by the Unitas Knowledge Centre in Australia. The book is a team effort and contributions were delivered by a dozen university and corporate researchers.

The project also produced a major report on the investigative research, a suite of tools, a manual, case studies, and supplementary publications all to be found at the Unitas-portal.

Relearning to e-learn focuses on how to implement efficient and effective e-learning in organisational settings: corporate e-learning. Although the contents of the book is written with that audience in mind, researchers and practitioners in educational context may find abundant information and knowledge that suit their needs to construct e-learning conditions.

The intention of the author is *to deconstruct some popular misconceptions and re-explores some basic principles of managing e-learning for individual businesses and community development*. He fears that the trend to trivialise the concept will inevitably lead to its fall, whereas deepening and exploring it will help to achieve tangible benefits for individuals, organisations and communities.

Chapter 1: What is e-learning gives an extensive description on processes, content and objects, (communication) technologies, trends in the use of the internet, bandwidth in relation to applications and emerging technologies such as handheld and wireless devices. It also defines the field and presents that in a clear and robust model. The book defines e-learning as a learning experience involving the acquisition or transfer of knowledge delivered or transacted through electronic means. In this definitions distance and flexible learning are not necessarily enclosed. This will be an eye-opener for those who combine the concept of both learning modes automatically with electronic delivery. Another pleasant surprise is the demystification of the metadata-hype. Dr. Bowles questions the reusability of learning objects as they have meaning in context. He also suspects (p. 8) the large vendors of IT and e-learning systems of fuelling the concepts popularity. A point to ponder! Every chapter concludes with a leading principle. Chapter 1 deliverers: E-learning encompasses a wide diversity of practices in a dynamic, rapidly changing field. It must therefore be defined to encompass all learning experiences involving the acquisition or transfer of knowledge. Would it not if the field was more at rest and evolutionary?

Chapter 2: The e-learning marketplace gives an overview on trends in e-learning but is troubled by the absence of a single definition. In such swamps it is hard to combine data to draw conclusions. In some cases, e.g. the S-curve on page 22, we could have done with more data to underpin the conclusions in this chapter. To some readers the preference for statistical evidence from the Australian continent and Asia may be less interesting than that of Europe and the America's.

I read *Chapter 3: Promises and Pitfalls* with great interest and pleasure and recommend every educational technologist to learn it by heart or to pin in to the bedroom wall. It gives an excellent overview of the e-learning ecosystem and describes the needs and expectations of all stakeholders. Figure 3.1. on page 49 on Blended E-Learning will no doubt be found in future publications. I think the part that dealt with concerns of ROI could better have been embedded in Chapter 12: Building Effective and Efficient e-learning.

Chapter 4: From competencies to capabilities summarises what is common knowledge today and also provides some input on the limitations of a competency approach. Nice to have in this day and age where everybody seem to proclaims this route. *Principal 4: Old paradigms based on e-training need to be revised to ensure that a focus on individual competence related to performance is augmented by targeting identity capabilities, which build purpose, shared meaning and a culture of collaboration.* I particularly like that because it reinforces the notion that learning is the collaborative construction of concepts. Carl Bereiter beautifully integrates this knowledge into his work in Toronto, Canada. Also missing is reference to the work of Jonassen on computers as mindtools. No doubt we will find reference to those two and more in the next edition.

Chapter 5: Dimensions of knowledge is a must for all. It brings the main issues together in a tidy presentation. Nonaka's knowledge spiral would have fitted nicely in this chapter and it still puzzles me why it wasn't used.

Chapter 6: Generating Knowledge through learning kindly summarises the different modes for learning and training and its (dis)advantages.

Chapter 7: Individual Factors in E-learning Performance lists what is known about cognition, intelligence and learning styles.

But why where these two chapters not bundled into one with the integration of the work of Lee Alley and Kate Jansak. They argue that instructional designers should learn more from the results of cognitive-psychological research and developed 10 'Principals of learning science' that embed the work of Bloom, Gardner and Gagne. A lead to follow I think.

Chapter 8: Toward Collaborative E-Learning, Chapter 9: Forces of Transformation, Chapter 10: Organisational E-Learning: Principles and Pressures and Chapter 11: Transactions and E-Services will please many that also feel the heat of the action. It gives, more than the other chapters, concrete guidelines and reaches out to the practitioner. I felt a bit lost though when studying figure 9.2 and 9.3 on page 122.

Chapter 12: Effective and Efficient E-learning deals with evaluation and costs. It gives concrete direction for evaluating e-learning activities but failed in my view on delivering at least a foundation for the evaluation of costs and return. Much excellent groundwork has been done here e.g. the publication of Greville Rumble: The costs and effectiveness of Open and Distance Learning from Kogan Press.

Relearning to e-learn; Strategies for electronic learning and knowledge is a good book and should be in your shelf for reference. It is critical and shows a number of fresh views and approaches. It integrates and combines disciplines in a pragmatic and leisurely way and also gives a good overview on most relevant domains. It delivers handy lists and some nice tables and figures. It is not easy reading, the language is condensed and littered with reference sometimes.

I do not find it a very tidy book, in the sense that it sometimes lacks consistency in style and depth of information. But maybe that is weaved in when you work with a team! Worrying is the omission of reference of much excellent research in the field in Europe and North America. Is our research not globally accessible today?

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Leaving School: Finding Education
(Book Review)

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Leaving School: Finding Education
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Overview

This book calls for a major paradigm shift in the US public education system. Its authors, after accumulating a wealth of experience in the public secondary sector, have come to the conclusion that schools have become increasingly unsuitable places in which to educate the young. The book explores in detail the path that has led public schooling to this apparent crisis, and offers some suggestions as to how learning might be better facilitated as we move into the 21st century.

Organised into seven chapters, the book explores the historical factors that have shaped public education in the United States and examines how schools, as learning institutions, have failed to adapt to the economic and social changes that have occurred in the post-war era. The book looks at a range of alternatives and arrives at twelve conclusions that present the case for a radically different approach.

Chapter Summary

The Preface and Chapter One leave no doubt in the reader's mind that, as far as Wiles and Lundt are concerned, schools – as centres of learning – have become something of an anachronism, and unless there is dramatic change, the sustainability of the education system (and the social fabric of the United States itself) will be under serious threat. The authors identify two key factors that have brought about this state of affairs: (i) schools simply not adapting to rapid technological progress; and (ii) schools becoming "fiscal and political prisoners of government" (p. 2).

Chapter Two offers a comprehensive history of the development of public schools in the United States. The authors describe in some detail how schools were shaped in the 20th century by legal decisions and economic considerations. They conclude that the development of schools has not kept pace with wider changes in society and that, in many respects, the modern day school is more suited to early 20th century society than the 'information age'. One particularly noteworthy item in this chapter is the authors' heartfelt belief that those *least* qualified to bring about the necessary reforms in education are those most entrenched in it. The authors believe that a paradigm shift can only occur with the support of people from outside of the education sector.

Chapter Three explores a number of factors that, in Wiles and Lundt's view, have contributed to the poor state of public schooling in the US. For example, they mention the inflexibility of the school calendar and how it evolved primarily to suit the requirements of an agrarian society. They look at how the current day curriculum is essentially based on the 19th century belief that the brain is a muscle which needs to be strengthened through increased cranial activity; a belief that led to the development of a knowledge set that was the same for all, with specific amounts of content to be covered by all students in order to give their "brain muscle" a work out. The authors argue that this 'one-size-fits-all' approach to education has been, and still is, detrimental to a large proportion of students.

Also contained in this chapter are some interesting observations about the teaching profession, particularly with respect to the incentives placed before teachers (or lack thereof). Wiles and Lundt make the point that, unlike many other professions, a teacher's salary is not linked to competence but to years of service. They also make the point that teachers are not held responsible for student outcomes and that performance review and accountability continue to be thorny issues.

Chapter Four opens with an overview of the social changes that have been experienced by US society in the post-war period such as the disintegration of the nuclear family, falling church attendance, the deterioration in neighbourhood schools, the increase in dual-income families, and the escalating use of day care and after school care. All these changes are considered by Wiles and Lundt to have had a dramatic (and generally detrimental) effect on schools. This already bad situation is then exacerbated by an increased political focus on schools around the issues of equity and academic excellence. This, say the authors, all adds up to a pretty bleak outlook for public schooling. However, what is most frustrating for the authors is the lack of vision within the public schooling system, especially when it comes to the use of the Internet as a tool to adapt to social change and facilitate a shift to the new technical paradigm.

Chapter Five presents the reader with some engaging discussion. The historical context dealt with, this is the chapter where the reader begins to get an insight into how Wiles and Lundt believe student learning might occur with greater efficacy. Having reached the conclusion that the "present system of education is broken beyond repair" (p. 123), the authors acknowledge that to change education so fundamentally will not be easy given vested interests and the sheer logistics of such a move. However, in contemplating change they present the reader with two attention-grabbing questions "What will the new education look like?" and "Who will be responsible for education in the future?"

They begin by reminding the reader that, as an institution, school is relatively new, and that it is essentially a 19^{th} century construct with the purpose of serving society as much as the individual. Schools are thus a medium of social control with individuals being educated "by the prescription of the school" (p. 125). This social control, say the authors, is at the expense of education. The remainder of the chapter is then devoted to exploration of alternative access points for learning where, according to Wiles and Lundt, real education can occur. In the process, they present some quite compelling arguments.

The most important point they make is epistemological; *viz.* the *acquisition* of knowledge is not enough, and that we should be more concerned about the *application* of knowledge. In the past teachers were seen as they only legitimate source of specific information. Today, however, huge volumes of information can be acquired quickly through the various information and communications technologies (ICTs), most significantly the Internet. They quote Alvin Toffler who observed that "the illiterate of 2000 and beyond will not be the individual who cannot read or write, but the one who cannot learn, unlearn, and relearn" (p. 130). In short, content is literally (and metaphorically!) at students' fingertips, it is how that content is interpreted and analysed that is important.

Wiles and Lundt make the dramatic but logical assertion that to move forward "educators will have to envision learning without school buildings" and that learning is "no longer place-bound, time-bound, or teacher-bound" (p. 142). The future they would like to see is one of learning communities, mentors to guide acquisition and application of knowledge, processes to validate learning, and knowledge being assessed in terms of its application value.

Chapter Six proffers some radical measures aimed at engineering a paradigm shift. Among other things, the authors advocate a national system of education particularly in the area of funding, a system that is child-centric, a funding model that is based on vouchers or an education tuition allowance, mandatory education between ages 3 and 12; and a year round school calendar .

Wiles and Lundt also envisage a broad range of educational institutions vying for students who have a federally funded educational allowance to spend (a higher allowance would be granted to those students deemed to have educational special needs). Within this new educational institution we could expect to see a mentoring system to guide and support young people through an individualised curriculum, using learning methodologies geared to specific learning styles. Students would also work at their own pace, at a time of their choosing. Full use would be made of the various ICTs, and much learning would occur over the Internet. Verification and evaluation of student achievements would be in the form of periodic testing of knowledge and skills, and educational institutions would be held accountable through a process of verification of student results and tracking of student outcomes.

Chapter Seven begins with a call for the public schools' monopoly on government funding to cease. The authors consider examples of how competition from the private sector has helped improve efficiency and provoked change in government monopolies. They argue that successful change requires appropriate use of emerging technologies and adaptation to changing social conditions. They also point out that there is no shortage of extant alternatives to public schools. The chapter then goes on to include brief descriptions of the plethora of alternative educational institutions currently operating in the US including, for example, home-schooling, democratic and free schools, Friends (Quaker) Schools, Montessori Schools, Waldorf Schools (Steiner Schools), and Therapeutic Schools. An important caveat is that most of these alternatives are schools that are *modifying* rather than *changing* how schooling is done. The real challenge, according to the authors, is to look *beyond* schools for the delivery of quality education.

Twelve Conclusions and a Postscript bring the book to a close – somewhat succinctly – with a summary of how public schools have declined in the 20th century as a result of government monopoly that has not responded to technical or social change. The discussion then ends in an optimistic fashion with the authors declaring that the system can change with the direct intervention of parents and other concerned individuals who demand a greater choice of educational experience for young people.

Summary and critique

In terms of the merits of the arguments put forward in this volume, the two former state secondary school teachers and dedicated disciples of e-learning who reviewed it did not need too much convincing. This was interesting read, written in an easy-to-absorb conversational style – maybe a little too conversational for the academic purists, but probably appropriate given the zeal with which the authors put forward their case.

In terms of structure, the book took a while to 'get going' given the quite extensive historical descriptions of the development of public education in the US. Whilst interesting, this sometimes contributed to a dilution of the potency of the message being conveyed. A structure focusing more sharply on the issues that have contributed to the demise of schools would help the reader get a better understanding as to why the authors believe there is a crisis in the schooling sector. Chapter Five of the book onwards is much more engaging. Had the authors given readers a clearer preview of what to expect in the first three or four chapters and justified how this was going to lead into the second half of the book, the text would have had even more appeal. For instance, providing the reader with a précis – prior to the historical discussion – as to what the authors considered to be the key factors that led them to conclude there is a crisis in public education would have been most instructive. As it is, these factors have to be drawn out from the opening chapters by the reader according to their own volition.

Another minor shortcoming of the book is that it unabashedly focuses on the US scene. This is perfectly understandable as the authors are US-based and clearly very passionate about what is unfolding in their 'own back yard', but there is little doubt that the inclusion of international comparisons would have strengthened their overall argument. It is unclear in the first chapter, for example, whether the authors perceive the problem to a purely US phenomenon or part of some international crisis due to economic and social changes on a global scale. What they go on to describe, of course, is not exclusive to the US although reading the book one could be forgiven for thinking that it is. This is all the more surprising given that both authors have a wealth of experience as consultants to many governments around the world.

In summary, this book is an impassioned plea on the part of two frustrated educators for society to think innovatively when it comes to public education. It presents the case that the public sector school faces a crisis as an outdated institution which, sadly, has become a victim of competing political agendas and ever-declining state funding. In response, Wiles and Lundt call for a refocus on quality learning and a student-centred approach to education. This refocus, they believe, can be readily achieved *now* if the education system took advantage of the opportunities presented by the various ICTs. Their optimistic conclusion is that change can occur if individuals and groups outside of the education monopoly assert their constitutional right for freedom of choice in education. If this goal is to be realised, it would certainly help if people outside of the mainstream education system read this book which, true to the authors' ideals, has been written, edited and published electronically without face-to-face contact.

Gilbert, J. (2004). Book review: Thank You, Brain For All You Remember: What You Forgot Was My Fault (William R. Klemm). *Educational Technology & Society*, 7 (4), 224-225.

Thank You, Brain For All You Remember: What You Forgot Was My Fault

(Book Review)

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9 chapters plus introduction and summary; 308 pages

This book claims to be aimed at anyone who wants to improve their memory but it might be better described as an aid for anyone wanting to improve their ability to learn. It is rather unusual in being much more than the average 'airport' bestseller which comprises merely memory tips for the lay reader hoping to improve themselves with very little outlay. The author attempts to find a middle way between the handy hints reader and the tome reporting on research findings aimed at other scientists. As such it fills an important gap in the market using both long established research findings and more recent studies to explain the functioning of the brain and justify the advice offered. The author is a Professor of Neuroscience at Texas A&M University and has been publishing research on brain function for more than 40 years. He has published many journal articles and a number of books. He states that the intended audience includes students, workers, senior citizens and 'anyone who wants to look smart'. I felt that the book was also suitable for teachers of all age groups who wish to provide some guidance to their students on how to learn and when and how to memorise. Not only does the author provide a practical guide for teachers but also a valuable resource for any reader's own learning. He successfully explains why we remember certain things, without appearing to make an effort, and yet cannot remember other, apparently, more important points.

Each chapter begins with a catchy, if somewhat gimmicky, title; a list of the main topics; a relevant quotation; and concludes with a tip list of key ideas. This format makes it easy to decipher the structure of the text and motivates one to dip in or look back for key points. While the book can be read from cover to cover I found myself jumping ahead to topics that appealed to me. In order to address this middle ground of advice for the lay person grounded in the research findings, the author adopts a style which varies from a casual, and often rather folksy, style which I found a little condescending to a more factual, descriptive style which he tended to use when reporting research findings. I personally preferred the latter style but maybe for the non-academic reader a relaxed style is more accessible. In addition the author sometimes references in an unconventional format. As an academic I found this a little irritating but my students have reported that they often find conventional referencing breaks up the text and interrupts their understanding of the flow of argument so I suspect that this approach may work well with the target audience.

Each chapter addresses a particular issue such as the need to pay attention, the value of sleep, the worries of memory loss associated with aging, the link between emotion and memory and the importance of association. By explaining the research which underpins the sort of the techniques that many of us already apply, such as the use of an acronym to remember the colours of the rainbow, Klemm helps us to make the necessary associations to understand and remember the key points. One useful distinction which he examines is the importance of registering information in the first place as opposed to the need to be able to recall that information. Thus we have to write the information to memory initially, and in order to do that, we have to pay attention and then we have to retrieve the information. He discusses a number of those tricky moments like the inability to remember the name of someone or the tip of the tongue experience and explains why we are more likely to recollect if we stop consciously thinking about the word we are searching for. Another distinction which he uses, though he does not really explain it, is the separation of mind and brain. He suggests that we all have brains which are capable of being used to much better effect and it is the job of the mind to harness the brain and put it to good use. He also makes a distinction between implicit and explicit understanding and between conscious and unconscious thought.

The book is sometimes gripping and mostly accessible. It is full of simple examples that we can all relate to and some fascinating research findings are presented. The basis for the memory tricks that we see on television are explained. However, the author had a tendency at times to labour the point and the empirical work could have been described more succinctly. Some of the experiments are described in considerable detail and it was at this point that I found myself, as a lay reader, interested only in the conclusions that could be drawn; I wanted to skip to the chase so I often skimmed the detail. But it is an easy book to dip into and read out of sequence. The main point made by the book is that our brains can store and recall a great deal providing we understand how to use the brain effectively and apply appropriate techniques.

The one aspect that I felt was missing from the book was the presentation of a final model of memory which collated and related all the findings and presented them in a coherent fashion. Perhaps the most effective way for the learner/reader to make sense and then remember all the guides to effective learning and memorising is to produce their own diagram or model to summarise the points. This book aims to be different and to go beyond mere tricks and gimmicks to probe the scientific basis for good memory. I think it succeeds and is suitable for anyone who really wants to improve their memory by understand more clearly how it works. In an era where rapid change is the norm and societies have an aging demographic profile the challenge to us all is to continue to learn. This book reassures us that it is possible even for those among us who are aging.

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