Towards Open Source Software Adoption and Dissemination

TOSSAD

Contract No 015981

Determining best F/OSS training methods

Document number

Version

0.5

Date

10.11.2005

Copyright

Version control

Version	Date	Author	Organization
0.5	10.11.05	Enn Õunapuu	TUT
1.0			

Change history

Release approval

Name	Role	Date

1. Learning theories

Theories of learning provide empirically-based accounts of the variables which influence the learning process, and provide explanations of the ways in which that influence occurs. In this review of learning theories we use materials of web page of JISC (http://www.jisc.ac.uk/) (Terry Mayes, Sara de Freitas. (2001)). The Joint Information Systems Committee (JISC) supports further and higher education by providing strategic guidance, advice and opportunities to use Information and Communications Technology (ICT) to support teaching, learning, research and administration. JISC is funded by all the UK post-16 and higher education funding councils.

There are distinct traditions in educational theory that derive from different perspectives about the nature of learning itself. At a theoretical level it is probably true to say that never before has there been such agreement about the psychological fundamentals. Here, we follow the approach of Greeno, Collins & Resnick (1996) in identifying three clusters or broad perspectives, which make fundamentally different assumptions about what is crucial for understanding learning. These are:

- The *associationist/empiricist* perspective (**learning as activity**)
- The *cognitive* perspective (**learning as achieving understanding**)
- The *situative* perspective (**learning as social practice**)

We consider how each of these has contributed differently to the design cycle of specifying learning outcomes, designing learning environments and teaching methods, and deriving appropriate assessment.

1.1 The associationist/empirical perspective – learning as activity

In this approach, knowledge is an organised accumulation of associations and killcomponents. Learning is the process of connecting the elementary mental or behavioural units, through sequences of activity. This view encompasses the research traditions of associationism, behaviourism and connectionism (neural networks). Associationist theory requires subject matter to be analysed as specific associations, expressed as behavioural objectives. This kind of analysis was developed by Gagnė (1985) into an elaborate system of instructional task analysis of discriminations, classifications and response sequences. Learning tasks are arranged in sequences based on their relative complexity according to a task analysis, with simpler components as pre-requisites for more complex tasks. The neural network approach views knowledge states as represented by patterns of activation in a network of elementary units. This approach has not yet been applied widely to educational issues, but is potentially significant. It suggests an analysis of knowledge in terms of attunement to regularities in the patterns of activities, rather than in terms of components, as traditional task analysis requires.

In this perspective learning is the formation, strengthening and adjustment of associations, particularly through the reinforcement of particular connections through feedback. One implication is the individualising of instruction, where each student responds actively to questions or problems and receives immediate feedback on their response. This has underpinned the development of programmed instruction and computer programmes that teach routine skills. The shaping of responses through selective reinforcement relates to instruction-by-approximation (in classroom contexts skilled teachers provide encouragement as students achieve better approximation to the required patterns of performance). Analysis of complex tasks into Gagnė's learning hierarchies – the decomposition hypothesis – involves the assumption that smaller units need to be mastered as a prerequisite for more complex units. Thus sequences of instruction are designed for students to be able to succeed by learning in small and logically-ordered steps. This assumption – that knowledge and skill needs to be taught from the bottom up - has been the subject of long controversy (eg Resnick & Resnick, 1991), but is still prevalent in elearning. However, it is worth underlining the point made by, for example, Wilson & Myers (2000), that although behaviourism is currently widely dismissed as a serious theoretical basis for education, and mistakenly often associated with a teacher-centred model of learning, this view is seriously wide of the mark. Behaviourism was centrally concerned to emphasise active learning-by-doing with immediate feedback on success, the careful analysis of learning outcomes, and above all with the alignment of learning objectives, instructional strategies and methods used to assess learning outcomes. Many of the methods with the label "constructivist" - constituting the currently accepted consensus on pedagogy amongst educational developers in HE – are indistinguishable from those derived from the associationist tradition.

1.1.1 Behaviorism

Definition
Behaviorism is a theory of animal and human learning that only focuses on objectively observable behaviors and discounts mental activities. Behavior theorists define learning as nothing more than the acquisition of new behavior.

Discussion
Experiments by behaviorists identify **conditioning** as a universal learning process. There are two different types of conditioning, each yielding a different behavioral pattern:

1. **Classic conditioning** occurs when a natural reflex responds to a stimulus. The most popular example is Pavlov's observation that dogs salivate when they eat or even see food. Essentially, animals and people are biologically "wired" so that a certain stimulus will produce a specific response.
2. **Behavioral** or **operant conditioning** occurs when a response to a stimulus is reinforced. Basically, operant conditioning is a simple feedback system: If a reward or reinforcement follows the response to a stimulus, then the response becomes more probable in the future. For example, leading behaviorist B.F. Skinner used reinforcement techniques to teach pigeons to dance and bowl a ball in a mini-alley.

There have been many criticisms of behaviorism, including the following:

1. Behaviorism does not account for all kinds of learning, since it disregards the activities of the mind.
2. Behaviorism does not explain some learning--such as the recognition of new language patterns by young children--for which there is no reinforcement mechanism.
3. Reserach has shown that animals adapt their reinforced patterns to new information. For instance, a rat can shift its behavior to respond to changes in the layout of a maze it had previously mastered through reinforcements.

How Behaviorism Impacts Learning

This theory is relatively simple to understand because it relies only on observable behavior and describes several universal laws of behavior. Its positive and negative reinforcement techniques can be very effective--both in animals, and in treatments for human disorders such as autism and antisocial behavior. Behaviorism often is used by teachers, who reward or punish student behaviors.

1.1.2 Neuroscience

Definition

Neuroscience is the study of the human nervous system, the brain, and the biological basis of consciousness, perception, memory, and learning.

Discussion

The nervous system and the brain are the physical foundation of the human learning process. Neuroscience links our observations about cognitive behavior with the actual physical processes that support such behavior. This theory is still "young" and is undergoing rapid, controversial development.

Some of the key findings of neuroscience are:

The brain has a triad structure. Our brain actually contains three brains: the lower or reptilian brain that controls basic sensory motor functions; the mammalian or limbic brain that controls emotions, memory, and biorhythms; and the neocortex or thinking brain that controls cognition, reasoning, language, and higher intelligence.

The brain is not a computer. The structure of the brain's neuron connections is loose, flexible, "webbed," overlapping, and redundant. It's impossible for such a system to function like a linear or parallel-processing computer. Instead, the brain is better described as a self-organizing system.

The brain changes with use, throughout our lifetime. Mental concentration and effort alters the physical structure of the brain. Our nerve cells (neurons) are connected by branches called dendrites. There are about 10 billion neurons in the brain and about 1,000 trillion connections. The possible combinations of connections is about ten to the one-millionth power. As we use the brain, we strengthen certain patterns of connection, making each connection easier to create next time. This is how memory develops.

How Neuroscience Impacts Education

When educators take neuroscience into account, they organize a curriculum around real experiences and integrated, "whole" ideas. Plus, they focus on instruction that promotes complex thinking and the "growth" of the brain. Neuroscience proponents advocate continued learning and intellectual development throughout adulthood.

1.1.3 Brain-based learning

Definition

This learning theory is based on the structure and function of the brain. As long as the brain is not prohibited from fulfilling its normal processes, learning will occur.

Discussion

People often say that everyone **can** learn. Yet the reality is that everyone **does** learn. Every person is born with a brain that functions as an immensely powerful processor. Traditional schooling, however, often inhibits learning by discouraging, ignoring, or punishing the brain's natural learning processes.

The core principles of brain-based learning state that:

1. The brain is a parallel processor, meaning it can perform several activities at once, like tasting and smelling.
2. Learning engages the whole physiology.
3. The search for meaning is innate.
4. The search for meaning comes through patterning.
5. Emotions are critical to patterning.
6. The brain processes wholes and parts simultaneously.
7. Learning involves both focused attention and peripheral perception.
8. Learning involves both conscious and unconscious processes.
9. We have two types of memory: spatial and rote.
10. We understand best when facts are embedded in natural, spatial memory.
11. Learning is enhanced by challenge and inhibited by threat.
12. Each brain is unique.

The three instructional techniques associated with brain-based learning are:

1. **Orchestrated immersion**--Creating learning environments that fully immerse students in an educational experience
2. **Relaxed alertness**--Trying to eliminate fear in learners, while maintaining a highly challenging environment
3. **Active processing**--Allowing the learner to consolidate and internalize information by actively processing it

How Brain-Based Learning Impacts Education

Curriculum--Teachers must design learning around student interests and make learning contextual.

Instruction--Educators let students learn in teams and use peripheral learning. Teachers structure learning around real problems, encouraging students to also learn in settings outside the classroom and the school building.

Assessment--Since all students are learning, their assessment should allow them to understand their own learning styles and preferences. This way, students monitor and enhance their own learning process.

What Brain-Based Learning Suggests

How the brain works has a significant impact on what kinds of learning activities are most effective. Educators need to help students have appropriate experiences and capitalize on those experiences. Three interactive elements are essential to this process:

- Teachers must immerse learners in complex, interactive experiences that are both rich and real. One excellent example is immersing students in a foreign culture to teach them a second language. Educators must take advantage of the brain's ability to parallel process.

- Students must have a personally meaningful challenge. Such challenges stimulate a student's mind to the desired state of alertness.

- In order for a student to gain insight about a problem, there must be intensive analysis of the different ways to approach it, and about learning in general. This is what's known as the "active processing of experience."

A few other tenets of brain-based learning include:
Feedback is best when it comes from reality, rather than from an authority figure.
People learn best when solving realistic problems.
The big picture can't be separated from the details.
Because every brain is different, educators should allow learners to customize their own environments.
The best problem solvers are those that laugh!
Designers of educational tools **must be artistic** in their creation of brain-friendly environments. Instructors need to realize that the best way to learn is not through lecture, but by participation in realistic environments that let learners try new things safely.

1.2 The cognitive perpective – learning as achieving understanding

As part of a general shift in theoretical positioning in psychology starting in the 1960s, learning, as well as perception, thinking, language and reasoning became seen as the output of an individual's attention, memory and concept formation processes. This approach provided a basis for analyzing concepts and procedures of subject matter curricula in terms of information structures, and gave rise to new approaches to pedagogy.
Within this broad perspective, particular sub-areas of cognitive research can be highlighted as particularly influential, e.g.: schema theory, information processing theories of problem solving and reasoning, levels of processing in memory, general competencies for thinking, mental models, and metacognitive processes. The underlying theme for learning is to model the processes of interpreting and constructing meaning, and a particular emphasis was placed on the instantiation of models of knowledge acquisition in the form of computer programmes (e.g.: Newell, 1990). Knowledge acquisition was viewed as the outcome of an interaction between new experiences and the structures for understanding that have already been created. So building a framework for *understanding* becomes the learner's key cognitive challenge. This kind of thinking stood in sharp contrast to the model of learning as the strengthening of associations.
The cognitive account saw knowledge acquisition as proceeding from a declarative form to a procedural, compiled form. As performance becomes more expert-like and fluent so the component skills become automatised. Thus, conscious attention is no longer required to monitor the low-level aspects of performance and cognitive resources are available for more strategic levels of processing. Thus the computer tutors developed by Anderson and co-workers (Anderson et al, recent refs) are all based on this expertise view of learning. Increasingly, mainstream cognitive approaches to learning have emphasised the assumptions of *constructivism* that understanding is gained through an active process of creating hypotheses and building new forms of understanding through *activity*. In schoollevel

educational research the influence of Piaget has been significant, in particular his assumption that conceptual development occurs through intellectual activity rather than by the absorption of information. Brown *et al* (1989) argued that we should consider concepts as tools, to be understood through use, rather than as self-contained entities to be delivered through instruction. This is the essence of the constructivist approach in which the learners' search for meaning through activity is central.

1.2.1 Costructivism

Definition
Constructivism is a philosophy of learning founded on the premise that, by reflecting on our experiences, we construct our own understanding of the world we live in. Each of us generates our own "rules" and "mental models," which we use to make sense of our experiences. Learning, therefore, is simply the process of adjusting our mental models to accommodate new experiences.

Discussion
There are several guiding principles of constructivism:

1. Learning is a search for meaning. Therefore, learning must start with the issues around which students are actively trying to construct meaning.
2. Meaning requires understanding **wholes** as well as parts. And parts must be understood in the context of wholes. Therefore, the learning process focuses on primary concepts, not isolated facts.
3. In order to teach well, we must understand the mental models that students use to perceive the world and the assumptions they make to support those models.
4. The purpose of learning is for an individual to construct his or her own meaning, not just memorize the "right" answers and regurgitate someone else's meaning. Since education is inherently interdisciplinary, the only valuable way to measure learning is to make the assessment part of the learning process, ensuring it provides students with information on the quality of their learning.

How Constructivism Impacts Learning
Curriculum--Constructivism calls for the elimination of a standardized curriculum. Instead, it promotes using curricula customized to the students' prior knowledge. Also, it emphasizes hands-on problem solving.

Instruction--Under the theory of constructivism, educators focus on making connections between facts and fostering new understanding in students. Instructors tailor their teaching strategies to student responses and encourage students to analyze, interpret, and predict information. Teachers also rely heavily on open-ended questions and promote extensive dialogue among students.

Assessment--Constructivism calls for the elimination of grades and standardized testing. Instead, assessment becomes part of the learning process so that students play a larger role in judging their own progress.

1.2.2 Piaget

Definition
Swiss biologist and psychologist Jean Piaget (1896-1980) is renowned for constructing a highly influential model of child development and learning. Piaget's theory is based on the

idea that the developing child builds cognitive structures--in other words, mental "maps," schemes, or networked concepts for understanding and responding to physical experiences within his or her environment. Piaget further attested that a child's cognitive structure increases in sophistication with development, moving from a few innate reflexes such as crying and sucking to highly complex mental activities**.**

Discussion
Piaget's theory identifies four developmental stages and the processes by which children progress through them. The four stages are:

1. *Sensorimotor stage (birth - 2 years old)*--The child, through physical interaction with his or her environment, builds a set of concepts about reality and how it works. This is the stage where a child does not know that physical objects remain in existence even when out of sight (object permanance).
2. *Preoperational stage (ages 2-7)*--The child is not yet able to conceptualize abstractly and needs concrete physical situations.
3. *Concrete operations (ages 7-11)*--As physical experience accumulates, the child starts to conceptualize, creating logical structures that explain his or her physical experiences. Abstract problem solving is also possible at this stage. For example, arithmetic equations can be solved with numbers, not just with objects.
4. *Formal operations (beginning at ages 11-15)*--By this point, the child's cognitive structures are like those of an adult and include conceptual reasoning.

Piaget outlined several principles for building cognitive structures. During all development stages, the child experiences his or her environment using whatever mental maps he or she has constructed so far. If the experience is a repeated one, it fits easily--or is assimilated--into the child's cognitive structure so that he or she maintains mental "equilibrium." If the experience is different or new, the child loses equilibrium, and alters his or her cognitive structure to accommodate the new conditions. This way, the child erects more and more adequate cognitive structures.

How Piaget's Theory Impacts Learning
Curriculum--Educators must plan a developmentally appropriate curriculum that enhances their students' logical and conceptual growth.

Instruction--Teachers must emphasize the critical role that experiences--or interactions with the surrounding environment--play in student learning. For example, instructors have to take into account the role that fundamental concepts, such as the permanence of objects, play in establishing cognitive structures.

1.2.3 Concept map

Concept maps are tools for organizing and representing knowledge, they are introduced by Joseph D. Novak (2005). They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts or propositions, indicated by a connecting line between two concepts. Words on the line specify the relationship between the two concepts. We define *concept as a perceived regularity in events or objects, or records of events or objects, designated by a label.* The label for most concepts is a word, although sometimes we use symbols such as + or %. *Propositions are statements about some object or event in the universe, either naturally occurring or constructed. Propositions contain two or more*

concepts connected with other words to form a meaningful statement. Sometimes these are called semantic units,or units of meaning. Figure 1 shows an example of a concept map that describes the structure of concept maps and illustrates the above characteristics.
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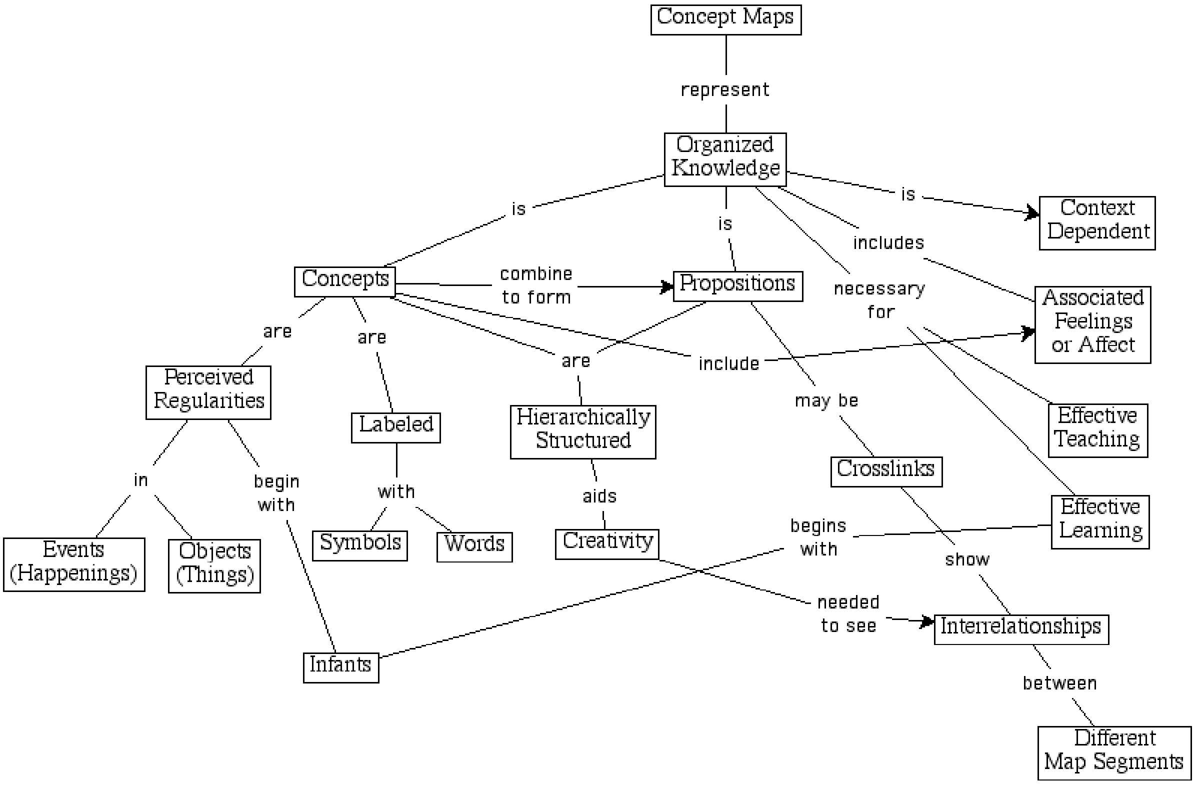

Figure 1

Another characteristic of concept maps is that the concepts are represented in a hierarchical fashion with the most inclusive, most general concepts at the top of the map and the more specific, less general concepts arranged hierarchically below. The hierarchical structure for a particular domain of knowledge also depends on the context in which that knowledge is being applied or considered. Therefore, it is best to construct concept maps with reference to some particular question we seek to answer or some situation or event that we are trying to understand through the organization of knowledge in the form of a concept map.
Another important characteristic of concept maps is the inclusion of "cross-links." These are relationships (propositions) between concepts in different domains of the concept map. Cross-links help us to see how some domains of knowledge represented on the map are related to each other.Inthe creation of new knowledge, cross-links often represent creative leaps on the part of the knowledge producer. There are two features of concept maps that are important in the facilitation of creative thinking: the hierarchical structure that is represented in a good map and the ability to search for and characterize cross-links.A final features that may be added to concept maps are specific examples of events or objects that help to clarify the meaning of a given concept.

1.3 The situative perspective – learning as social practice

The social perspective on learning has received a major boost from the reconceptualisation of all learning as 'situated'. A learner will always be subjected to influences from the social and cultural setting in which the learning occurs, which will also define at least partly the learning outcomes. This view of learning focuses on the way knowledge is distributed socially. When knowledge is seen as situated in the practices of communities then the outcomes of learning involve the abilities of individuals to participate in those practices successfully. The focus shifts right away from analyses of components of subtasks, and onto the patterns of successful practice. This can be seen as a necessary correction to theories of learning in which both the behavioural and cognitive levels of analysis had become disconnected from the social. Underlying both the situated learning and constructivist perspectives is the assumption that learning must be personally meaningful, and that this has very little to do with the informational characteristics of a learning environment. Activity, motivation and learning are all related to a need for a positive sense of identity (or positive self-esteem), shaped by social forces.

As Barab & Duffy (1999) point out, there are at least two 'flavours' to situated learning. One can be regarded as a socio-psychological view of situativity. This emphasises the importance of context-dependent learning in informal settings. This activity-based view of situated learning led to the design of what Barab & Duffy call '*practice fields*'. These represent constructivist tasks in which every effort is made to make the learning activity authentic to the social context in which the skills or knowledge are normally embedded. Example of approaches to the design of practice fields are problem-based learning. Here, the main design emphasis is on the relationship between the nature of the learning task in educational or training environments, and its characteristics when situated in real use.

The second idea is that with the concept of a community of practice comes an emphasis on the individual's relationship with a *group of people* rather than the relationship of an activity itself to the wider practice, even though it is the practice itself that identifies the community. This provides a different perspective on what is 'situated'. Lave and Wenger (1991) characterised learning of practices as processes of participation in which beginners are initially relatively peripheral in the activities of a community and as they learn the practices their participation becomes more central. For an environment of apprenticeship to be a productive environment of learning there need to be opportunities for learners to observe and then practice activities which move them into more 'legitimate' participation in the community. Lave and Wenger emphasised how a learner's identity derives from becoming part of a community of practice.

1.3.1 Communities of practice

Definition

This approach views learning as an act of membership in a "community of practice." The theory seeks to understand both the structure of communities and how learning occurs in them.

Basic Elements

The communities of practice concept was pioneered by the Institute for Research on Learning, a spin-off of the Xerox Corporation in Palo Alto, CA. The Institute pursues a cross-disciplinary approach to learning research, involving cognitive scientists, organizational anthropologists, and traditional educators. Communities of practice is based on the following assumptions:

Learning is fundamentally a social phenomenon. People organize their learning around the social communities to which they belong. Therefore, schools are only powerful learning environments for students whose social communities coincide with that school.

Knowledge is integrated in the life of communities that share values, beliefs, languages, and ways of doing things. These are called **communities of practice**. Real knowledge is integrated in the doing, social relations, and expertise of these communities.

The processes of learning and membership in a community of practice are inseparable. Because learning is intertwined with community membership, it is what lets us belong to and adjust our status in the group. As we change our learning, our identity--and our relationship to the group--changes.

Knowledge is inseparable from practice. It is not possible to **know** without **doing**. By doing, we learn.

Empowerment--or the ability to contribute to a community--creates the potential for learning. Circumstances in which we engage in real action that has consequences for both us and our community create the most powerful learning environments.

How Communities of Practice Impacts Education

This approach to learning suggests teachers understand their students' communities of practice and acknowledge the learning students do in such communities. The communities of practice theory also suggests educators structure learning opportunities that embed knowledge in both work practices and social relations--for example, apprenticeships, school-based learning, service learning, and so on. Plus, educators should create opportunities for students to solve real problems with adults, in real learning situations.

1.3.2 Control theory

Definition
This theory of motivation proposed by William Glasser contends that behavior is never caused by a response to an outside stimulus. Instead, the control theory states that behavior is inspired by what a person wants most at any given time: survival, love, power, freedom, or any other basic human need.

Discussion
Responding to complaints that today's students are "unmotivated," Glasser attests that all living creatures "control" their behavior to maximize their need satisfaction. According to Glasser, if students are not motivated to do their schoolwork, it's because they view schoolwork as irrelevant to their basic human needs.

Boss teachers use rewards and punishment to coerce students to comply with rules and complete required assignments. Glasser calls this "leaning on your shovel" work. He shows how high percentages of students recognize that the work they do--even when their teachers praise them--is such low-level work.

Lead teachers, on the other hand, avoid coercion completely. Instead, they make the intrinsic rewards of doing the work clear to their students, correlating any proposed assignments to the students' basic needs. Plus, they only use grades as temporary indicators of what has and hasn't been learned, rather than a reward. Lead teachers will "fight to protect" highly engaged, deeply motivated students who are doing quality work from having to fulfill meaningless requirements.

How the Control Theory Impacts Learning
Curriculum--Teachers must negotiate both content and method with students. Students' basic needs literally help shape **how** and **what** they are taught.

Instruction--Teachers rely on cooperative, active learning techniques that enhance the power of the learners. Lead teachers make sure that all assignments meet some degree of their students' need satisfaction. This secures student loyalty, which carries the class through whatever relatively meaningless tasks might be necessary to satisfy official requirements.

Assessment--Instructors only give "good grades"--those that certify quality work--to satisfy students' need for power. Courses for which a student doesn't earn a "good grade" are not recorded on that student's transcript. Teachers grade students using an absolute standard, rather than a relative "curve."

1.3.3 Observational learning

Definition
Observational learning, also called social learning theory, occurs when an observer's behavior changes after viewing the behavior of a model. An observer's behavior can be affected by the positive or negative consequences--called vicarious reinforcement or vicarious punishment--of a model's behavior.

Discussion
There are several guiding principles behind observational learning, or social learning theory:

1. The observer will imitate the model's behavior if the model possesses characteristics--things such as talent, intelligence, power, good looks, or popularity--that the observer finds attractive or desirable.
2. The observer will react to the way the model is treated and mimic the model's behavior. When the model's behavior is rewarded, the observer is more likely to reproduce the rewarded behavior. When the model is punished, an example of vicarious punishment, the observer is less likely to reproduce the same behavior.
3. A distinction exists between an observer's "acquiring" a behavior and "performing" a behavior. Through observation, the observer can acquire the behavior without performing it. The observer may then later, in situations where there is an incentive to do so, display the behavior.
4. Learning by observation involves four separate processes: *attention, retention, production and motivation*.
   - Attention: Observers cannot learn unless they pay attention to what's happening around them. This process is influenced by characteristics of the model, such as how much one likes or identifies with the model, and by characteristics of the observer, such as the observer's expectations or level of emotional arousal.
   - Retention: Observers must not only recognize the observed behavior but also remember it at some later time. This process depends on the observer's ability to code or structure the information in an easily remembered form or to mentally or physically rehearse the model's actions.
   - Production: Observers must be physically and/intellectually capable of producing the act. In many cases the observer possesses the necessary responses. But sometimes, reproducing the model's actions may involve skills

the observer has not yet acquired. It is one thing to carefully watch a circus juggler, but it is quite another to go home and repeat those acts.
    - Motivation: In general, observers will perform the act only if they have some motivation or reason to do so. The presence of reinforcement or punishment, either to the model or directly to the observer, becomes most important in this process.
5. Attention and retention account for acquisition or learning of a model's behavior; production and motivation control the performance.
6. Human development reflects the complex interaction of the person, the person's behavior, and the environment. The relationship between these elements is called *reciprocal determinism*. A person's cognitive abilities, physical characteristics, personality, beliefs, attitudes, and so on influence both his or her behavior and environment. These influences are reciprocal, however. A person's behavior can affect his feelings about himself and his attitudes and beliefs about others. Likewise, much of what a person knows comes from environmental resources such as television, parents, and books. Environment also affects behavior: what a person observes can powerfully influence what he does. But a person's behavior also contributes to his environment.

How Observational Learning Impacts Learning:

Curriculum-- Students must get a chance to observe and model the behavior that leads to a positive reinforcement.

Instruction-- Educators must encourage collaborative learning, since much of learning happens within important social and environmental contexts.

Assessment--A learned behavior often cannot be performed unless there is the right environment for it. Educators must provide the incentive and the supportive environment for the behavior to happen. Otherwise, assessment may not be accurate.

1.3.4 Vygotsky and Social Cognition

Definition
The social cognition learning model asserts that culture is the prime determinant of individual development. Humans are the only species to have created culture, and every human child develops in the context of a culture. Therefore, a child's learning development is affected in ways large and small by the culture--including the culture of family environment--in which he or she is enmeshed Vygotsky (1978).

Discussion

1. Culture makes two sorts of contributions to a child's intellectual development. *First*, through culture children acquire much of the content of their thinking, that is, their knowledge. *Second*, the surrounding culture provides a child with the processes or means of their thinking, what Vygotskians call the tools of intellectual adaptation. In short, according to the social cognition learning model, culture teaches children both what to think and how to think.
2. Cognitive development results from a dialectical process whereby a child learns through problem-solving experiences shared with someone else, usually a parent or teacher but sometimes a sibling or peer.

3. Initially, the person interacting with child assumes most of the responsibility for guiding the problem solving, but gradually this responsibility transfers to the child.
4. Language is a primary form of interaction through which adults transmit to the child the rich body of knowledge that exists in the culture.
5. As learning progresses, the child's own language comes to serve as her primary tool of intellectual adaptation. Eventually, children can use internal language to direct their own behavior.
6. Internalization refers to the process of learning--and thereby internalizing--a rich body of knowledge and tools of thought that first exist outside the child. This happens primarily through language.
7. A difference exists between what child can do on her own and what the child can do with help. Vygotskians call this difference the zone of proximal development.
8. Since much of what a child learns comes form the culture around her and much of the child's problem solving is mediated through an adult's help, it is wrong to focus on a child in isolation. Such focus does not reveal the processes by which children acquire new skills.
9. Interactions with surrounding culture and social agents, such as parents and more competent peers, contribute significantly to a child's intellectual development.

How Vygotsky Impacts Learning:
Curriculum--Since children learn much through interaction, curricula should be designed to emphasize interaction between learners and learning tasks.

Instruction--With appropriate adult help, children can often perform tasks that they are incapable of completing on their own. With this in mind, scaffolding--where the adult continually adjusts the level of his or her help in response to the child's level of performance--is an effective form of teaching. Scaffolding not only produces immediate results, but also instills the skills necessary for independent problem solving in the future.

Assessment--Assessment methods must take into account the zone of proximal development. What children can do on their own is their level of actual development and what they can do with help is their level of potential development. Two children might have the same level of actual development, but given the appropriate help from an adult, one might be able to solve many more problems than the other. Assessment methods must target both the level of actual development and the level of potential development.

2 Learning Styles

Definition
This approach to learning emphasizes the fact that individuals perceive and process information in very different ways. The learning styles theory implies that how much individuals learn has more to do with whether the educational experience is geared toward their particular style of learning than whether or not they are "smart." In fact, educators should not ask, "Is this student smart?" but rather "How is this student smart?"

Discussion
The concept of learning styles is rooted in the classification of psychological types (Gardner (1993)). The learning styles theory is based on research demonstrating that, as the result of heredity, upbringing, and current environmental demands, different individuals have a tendency to both perceive and process information differently. The different ways of doing so are generally classified as:

1. ***Concrete** and **abstract** perceivers*--Concrete perceivers absorb information through direct experience, by doing, acting, sensing, and feeling. Abstract perceivers, however, take in information through analysis, observation, and thinking.
2. ***Active** and **reflective** processors*--Active processors make sense of an experience by immediately using the new information. Reflective processors make sense of an experience by reflecting on and thinking about it.

Traditional schooling tends to favor abstract perceiving and reflective processing. Other kinds of learning aren't rewarded and reflected in curriculum, instruction, and assessment nearly as much.

How the Learning Styles Theory Impacts Education
Curriculum--Educators must place emphasis on intuition, feeling, sensing, and imagination, in addition to the traditional skills of analysis, reason, and sequential problem solving.

Instruction--Teachers should design their instruction methods to connect with all four learning styles, using various combinations of experience, reflection, conceptualization, and experimentation. Instructors can introduce a wide variety of experiential elements into the classroom, such as sound, music, visuals, movement, experience, and even talking.

Assessment--Teachers should employ a variety of assessment techniques, focusing on the development of "whole brain" capacity and each of the different learning styles.

2.1 Multiple intelligences

Definition

This theory of human intelligence, developed by psychologist Howard Gardner, suggests there are at least seven ways that people have of perceiving and understanding the world. Gardner labels each of these ways a distinct "intelligence"--in other words, a set of skills allowing individuals to find and resolve genuine problems they face.

Discussion
Gardner (1993) defines an "intelligence" as a group of abilities that:

Is somewhat autonomous from other human capacities. Has a core set of information-processing operations. Has a distinct history in the stages of development we each pass through plausible roots in evolutionary history

While Gardner suggests his list of intelligences may not be exhaustive, he identifies the following seven:

1. *Verbal-Linguistic*--The ability to use words and language;
2. *Logical-Mathematical*--The capacity for inductive and deductive thinking and reasoning, as well as the use of numbers and the recognition of abstract patterns;
3. *Visual-Spatial*--The ability to visualize objects and spatial dimensions, and create internal images and pictures;
4. *Body-Kinesthetic*--The wisdom of the body and the ability to control physical motion;
5. *Musical-Rhythmic*--The ability to recognize tonal patterns and sounds, as well as a sensitivity to rhythms and beats:
6. *Interpersonal*--The capacity for person-to-person communications and relationships;
7. *Intrapersonal*--The spiritual, inner states of being, self-reflection, and awareness.

How Multiple Intelligences Impact Learning

Curriculum--Traditional schooling heavily favors the verbal-linguistic and logical-mathematical intelligences. Gardner suggests a more balanced curriculum that incorporates the arts, self-awareness, communication, and physical education.

Instruction--Gardner advocates instructional methods that appeal to all the intelligences, including role playing, musical performance, cooperative learning, reflection, visualization, story telling, and so on.

Assessment--This theory calls for assessment methods that take into account the diversity of intelligences, as well as self-assessment tools that help students understand their intelligences.

Right Brain vs. Left Brain

Definition
This theory of the structure and functions of the mind suggests that the two different sides of the brain control two different "modes" of thinking. It also suggests that each of us prefers one mode over the other.

Discussion
Experimentation has shown that the two different sides, or hemispheres, of the brain are responsible for different manners of thinking. The following table illustrates the differences between left-brain and right-brain thinking:

Left Brain	**Right Brain**
Logical	Random
Sequential	Intuitive

Rational	Holistic
Analytical	Synthesizing
Objective	Subjective
Looks at parts	Looks at wholes

Most individuals have a distinct preference for one of these styles of thinking. Some, however, are more whole-brained and equally adept at both modes. In general, schools tend to favor left-brain modes of thinking, while downplaying the right-brain ones. Left-brain scholastic subjects focus on logical thinking, analysis, and accuracy. Right-brained subjects, on the other hand, focus on aesthetics, feeling, and creativity.

How Right-Brain vs. Left-Brain Thinking Impacts Learning

Curriculum--In order to be more "whole-brained" in their orientation, schools need to give equal weight to the arts, creativity, and the skills of imagination and synthesis.

Instruction--To foster a more whole-brained scholastic experience, teachers should use instruction techniques that connect with both sides of the brain. They can increase their classroom's right-brain learning activities by incorporating more patterning, metaphors, analogies, role playing, visuals, and movement into their reading, calculation, and analytical activities.

Assessment--For a more accurate whole-brained evaluation of student learning, educators must develop new forms of assessment that honor right-brained talents and skills.

3 Open-Source learning

At universities visions of learning communities, open development and exchange of ideas and useful services is one of direction of institutional culture growth. This is comparable with open-source software movement. Since higher education and the open-source software movement share common values, it is possible that higher education might use an open-source model for creation their curriculum. The main idea is that in higher education and elsewhere the advantages to be gained through the open development and exchange of ideas. The open-source development can be divided to the two categories:

- open-source courseware development,
- open-source knowledgeware development – the tools.

MIT's partnership with Stanford on the Open Knowledge Initiative (http://web.mit.edu/oki/) is an example of a project designed to develop a learning management system – web based tools for storing, retrieving, and disseminating educational resources and activities.
Projects such as MIT's OpenCourseWare effort (http://web.mit.edu/ocw/), which aims to make instructional materials available free on the web, and MERLOT project (http://www.merlot.org/Home.po), which endeavors to place on the web knowlwdge objects that have been evaluated for quality, represents variations on an open-source courseware development process.

3.1 Open CourseWare

MIT OpenCourseWare (MIT OCW) makes the course materials that are used in the teaching of almost all MIT's undergraduate and graduate subjects available on the Web, free of charge, to any user anywhere in the world. MIT OCW is a large-scale, Web-based publication of MIT course materials, and is not a degree-granting or credit-bearing initiative. MIT OCW would not be possible without the support and generosity of the MIT faculty who choose to share their research, pedagogy, and knowledge to benefit others.
The MIT OCW project aligns closely with MIT's institutional mission (*to advance knowledge and education and serve the world*) and is true to MIT's values of excellence, innovation, and leadership.
MIT faculty share a passion for teaching and contributing to their field of study. The MIT OCW staff strives to support the MIT faculty by:
Helping faculty put their course materials online for teaching
Providing a vehicle for faculty to share their ideas and contribute to their discipline
With 1100 courses now available, we expect MIT OCW to reach a steady — though never static — state by 2007. Between now and then, we will publish the materials from virtually all of MIT's undergraduate and graduate courses.

3.2 Open Knowledge Initiative

Phase 1
The Open Knowledge Initiative started at MIT in 2001 with funding from the Andrew W. Mellon Foundation. O.K.I. completed its first phase in July 2003 with delivery of the following:

A set of specifications that define interactions between educational software modules, programs, and systems within and across institutions.

Open source code for a reference implementation of each specification, with documentation of the architectural assumptions that underlie the specifications.

Open source code demonstrating the application of OSIDs to achieve service level interoperability.

Phase 2

Having provided the architectural framework for a new educational infrastructure, O.K.I. seeks to create and sustain a community where both open source and commercially licensed products can evolve. To achieve this, O.K.I. has the following goals:

- Maintain and refine the core specifications
- Research and develop new educational interoperability specifications
- Build a global developer community by providing developer training and access to information

Advance customer adoption of O.K.I. educational software by helping educational institutions and vendors learn and implement the architecture

4. e-learning

4.1 Learning objects

4.1.1 Learning object definition

Technology is an agent of change, and major technological innovations can result in entire paradigm shifts. The computer network known as the Internet is one such innovation. After affecting sweeping changes in the way people communicate and do business, the Internet is poised to bring about a paradigm shift in the way people learn. Consequently, a major change may also be coming in the way educational materials are designed, developed, and delivered to those who wish to learn. An instructional technology called "learning objects" currently leads other candidates for the position of technology of choice in the next generation of instructional design, development, and delivery, due to its potential for reusability, generativity, adaptability, and scalability.

Learning objects are elements of a new type of computer-based instruction grounded in the object-oriented paradigm of computer science. Object-orientation highly values the creation of components (called "objects") that can be reused in multiple contexts. This is the fundamental idea behind learning objects: instructional designers can build small (relative to the size of an entire course) instructional components that can be reused a number of times in different learning contexts. Additionally, learning objects are generally understood to be digital entities deliverable over the Internet, meaning that any number of people can access and use them simultaneously (as opposed to traditional instructional media, such as an overhead or video tape, which can only exist in one place at a time). Moreover, those who incorporate learning objects can collaborate on and benefit immediately from new versions. These are significant differences between learning objects and other instructional media that have existed previously.

To facilitate the widespread adoption of the learning objects approach, the Learning Technology Standards Committee (LTSC) of the Institute of Electrical and Electronics Engineers (IEEE) formed in 1996 to develop and promote instructional technology standards. Without such standards, universities, corporations, and other organizations around the world would have no way of assuring the interoperability of their instructional technologies, specifically their learning objects. A similar project called the Alliance of Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE) had already started with the financial support of the European Union Commission. At the same time, another venture called the Instructional Management Systems (IMS) Project was just beginning in the United States, with funding from Educom. Each of these and other organizations began developing technical standards to support the broad deployment of learning objects.

Definition:

Learning Objects are defined here as any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning. Examples of technology-supported learning include computer-based training systems, interactive learning environments, intelligent computer-aided instruction systems, distance learning systems, and collaborative learning environments. Examples of Learning Objects include multimedia content, instructional content, learning objectives, instructional software and software tools, and persons, organizations, or events referenced during technology supported learning.

The goal of learning objects projects is:

To enable computer agents to automatically and dynamically compose personalized lessons for an individual learner.

Reigeluth (1999) defines instructional design theory as follows:
Instructional design theories are design oriented, they describe methods of instruction and the situations in which those methods should be used, the methods can be broken into simpler component methods, and the methods are probabilistic.

4.1.2 Learning objects taxonomies

The discussion of learning object characteristics, such as sequence, scope, and structure, leads one to consider what different types of learning objects might exist. In other words, can types of learning objects be meaningfully differentiated?
All learning objects have certain qualities. It is the difference in the degree to which (or manner in which) they exhibit these qualities that makes one type of learning object different from another. The following taxonomy differentiates between five learning object types. Examples of these five object types are given below, followed by the taxonomy, which explicates their differences and similarities.
Fundamental - For example, a JPEG of a hand playing a chord on a piano keyboard.
Combined-closed - For example, a video of a hand playing an arpeggiated chord on a piano keyboard with accompanying audio.
Combined-open - For example, a web page dynamically combining the previously mentioned JPEG and QuickTime file together with textual material "on the fly."
Generative-presentation - For example, a JAVA applet capable of graphically generating a set of staff, clef, and notes, and then positioning them appropriately to present a chord identification problem to a student.
Generative-instructional - For example, an EXECUTE instructional transaction shell (Merrill, 1999), which both instructs and provides practice for any type of procedure, for example, the process of chord root, quality, and inversion identification.

4.2 E-learning standards

4.2.1 IEEE

Institute for Electrical and Electronic Engineers Learning Technology Standards Committee (IEEE LTSC) www.ltsc.ieee.org.
The IEEE is an international organization that develops technical standards and recommendations for electrical, electronic, computer and communication systems. IEEE specifications are already widely adopted and becoming international standards. Within the IEEE, the Learning Technology Standards Committee (LTSC) provides specification that address best practices, which can be tested for conformance. The most widely acknowledged IEEE LTSC specification is the Learning Object Metadata (LOM) specification, which defines element groups and elements that describe learning resources. The IMS and ADL both use the LOM elements and structures in their specifications.

4.2.2 IMS

IMS Global Consortium (IMS) www.imsproject.org
The IMS is a consortium of vendors and implementers who focus on the development of XML-based specifications. These specifications describe the key characteristics of courses,

lessons, assessments, learners and groups. In addition, the XML specifications and Best Practices Guidelines provide a structure for representing eLearning meta-data (defined as data about the data). This group offers a disciplined approach for describing the various resources and provides a common set of elements that can be exchanged between multiple systems and products. Describing eLearning resources helps you search through them for existing resources, exchange resources and data with others, and better manage the maintenance of these resources through their life cycles. The most widely acknowledged IMS specifications are as follows:
IMS Meta-data, IMS Content Packaging and IMS QTI (Question and Test Interchange).

4.2.3 SCORM

The ADL is a U.S. government-sponsored organization that researches and develops specifications to encourage the adoption and advancement of eLearning. The purpose of the ADL is to ensure access to high-quality education and training materials that can be tailored to fit individual needs and made easily available. The ADL's combination of research and recommendation helps turn the specifications into standards.
The most widely accepted ADL publication is the ADL Shareable Content Object Reference Model (SCORM). The SCORM specification combines elements of IEEE, AICC and IMS specifications into a consolidated document that can be easily implemented. The ADL adds value to existing standards by providing examples, best practices and clarifications that help suppliers and content developers implement eLearning specifications in a consistent and reusable way.

4.3 Decision Support Techniques in adaptive learning systems

The Internet has radically changed the way in which we learn and teach. E-learning systems are often not addressing fundamental business objectives and are not being rigorously evaluated. E-learning is being approached as a technical solution rather than a business solution. In this paper we investigate and implement a methodology for web service execution measurement from an educational organization perspective. In nearest future in the web will exist a lot of web services and it will be common that we have to choose one or some from them. For example in the case of tutorial systems we have to choose among various tutorial services according to the profile of the learner. In this case we need a regular component for the multi-criteria decision analysis of the learner profile. This component can be adaptive and have also some learning features.

4.3.1 Introduction

In the past, applications were built by integrating local system services such as database systems and development tools. That model was very flexible in providing access to a rich set of development resources and precise control over how the application behaved; however, although it was error prone, it was costly and time consuming. To get real results every enterprise creates its own system and component reuse is manifested, but not really used.
Today, complex distributed applications are being constructed that integrate existing applications and services from all over their networks (Allen (2001), Chappel et al (2001)). The service itself is structured as n-tier application with tiers such as business entities, data entities, and facades. This enables developers to focus on delivering business value. The result is reduced time-to-market, higher developer productivity, and ultimately, higher-quality software. We are now entering the next phase of computing - a phase enabled by the Internet and the concept of web services, which enables the creation of powerful applications that can be used by anyone, anywhere.
This paper describes a solution to the web services choice from the set of the similar web services from the performance measurement perspective of educational organization. The performance of organization depends on performances of business processes.
The usage of web services introduces a new set of fundamental architectural elements for architects to work with. These are web services, messages, contract, state, and processes, service agents, balanced scorecard, which are introduced in this paper. Finally we present a decision support component

4.3.2 Basic concepts

The next section is a brief introduction to the key concepts, followed by the details of the architecture. Basic concepts are component, software service agent, web service, message, state and process.

Software component

A software component is *a unit of composition* that is designed to be reused and combined with other components into larger software entities, in the same way that mechanical and electronic components are used today. In this paper we define the concept and derive a model

of what we mean by a component. Finally we look at how these components can be reused and combined.
There is no universally accepted definition for a software component. The component definition given below is taken from [16].
Definition*: A software component is a unit of composition with contractually specified interfaces and context dependencies only. A software component can be deployed independently and is subject to composition by third parties*

Web service

The term **"Web service"** is broadly applicable to a wide variety of network based application topologies. In this paper, we use the term "Web service" to describe application **components** whose functionality and interfaces are exposed to potential users through the application of existing and emerging Web technology standards including XML, SOAP, WSDL, and HTTP. In contrast to Web sites, browser-based interactions or platform-dependent technologies, Web services are services offered computer-to-computer, via defined formats and protocols, in a platform-independent and language-neutral manner. **Software services** are discrete units of application logic that expose message-based interfaces suitable for being accessed across a network. Service-based architectures permit very flexible deployment strategies; rather than requiring that all data and logic be resident on a single computer, the service model allows applications to leverage networked computational resources. This paper describes an application architecture that depends on interoperable services for the provision of high-value business logic and state management.

Message, state, contract, policy, processes

Message
In the service model presented here, the service is defined purely by the messages it will accept and produce, including the sequencing requirements for those messages. Successful routing of messages between services is a complex process, which is best handled by a messaging infrastructure shared across the services an organization exposes. This document explores these concepts in detail, presenting a conceptual view of the role of messages and message passing in a service-based architecture.
State
A service manages states; every state is the very reason for service existence. Services guard states and they ensure through their business logic that those are kept consistent and accurate. Service state is the only true and current source of information.
Contract
Services communicate through service interfaces, which send and receive messages. Service-to-service communication follows a contract, and by making this contract explicit it is possible to change one service implementation without compromising the interaction.
Policy
Services need to be managed and secured. A policy consists of a set of rules, and each rule applies to an aspect of the run-time behavior. For instance, a service may have multiple interfaces; you may have rules that apply to the service as a whole and you may have rules that apply to one or more of its interfaces.
Processes
Business processes control the step-by-step actions of executing work, moving the system from one state to another. At each step, a business operation is called. These processes can be hosted in a business process service or process service. A process in such a process service

will send a message to call a business operation contained within a service, and then move on to the next step, which may require the use of a different service.

Service agent

Software agent. Acting on behalf of another entity is the first fundamental property of agency. The agents exhibit a second fundamental agent characteristic, namely, they enjoy at least a variable degree of ***autonomy***. For example, estate agents can generally make viewing appointments for unoccupied properties without reference to the owners. A third important aspect of an agent's behavior is the degree of ***proactivity*** and ***reactivity*** present in their behavior. For instance, an estate agent who simply places a 'For Sale' sign outside a property for sale and waits for purchasers to come into his shop is behaving in a much more reactive fashion, than an agent who proactively advertises the property in the local press. It should be noted however that reactivity and proactivity are not flip sides of the same coin. The same agent can display high amounts of both proactivity and reactivity at different times. Finally, agents also exhibit some level of a number of attributes, the key ones of which are ***learning, cooperation and mobility***.

In our solution we use service agents.

A *service agent* is a agent that helps you work with other services. Often supplied by the provider of the target service, the agent runs topologically close to the application consuming the service. It helps both to prepare requests to a service and to interpret responses from the service. Typical advantages that service agents can offer include:

Ease of integration. Using agents to talk to remote services may simplify the development process. For example, a service agent may offer a language binding that makes calls to the service look like local method calls.

Error handling. Reacting correctly to error conditions is one of the hardest tasks for the developer of a service-consuming application. Service agents can be designed to understand the errors that a service can produce, greatly simplifying integration efforts. In our approach the special BIT interface for error handling is introduced.

Data handling. A service agent may be designed to cache data from the service in a correct and knowledgeable manner. This can greatly improve response times from a service, reduce load on the service, and permit applications to work in a disconnected (offline) state.

Request validation. Service agents can check the input document of a service request to ensure correctness prior to submission, allowing obvious errors to be caught without the lag time and server load of a roundtrip. This does *not* relieve the service of the need to validate all requests on receipt; the service can neither be certain the request was prepared by the agent, nor trust a service agent running in "hackable" environments outside of its organizational control.

Intelligent routing. Some services might use agents to send requests to a specific service instance based on the content of the request.

4.3.3 System architecture

The foundations for creation of intelligent e-learning systems is developed in ARIADNE system Duval (2003).

The basic units of intelligent e-learning system architecture are web services. Some services are supported by service agents (Fig 2).

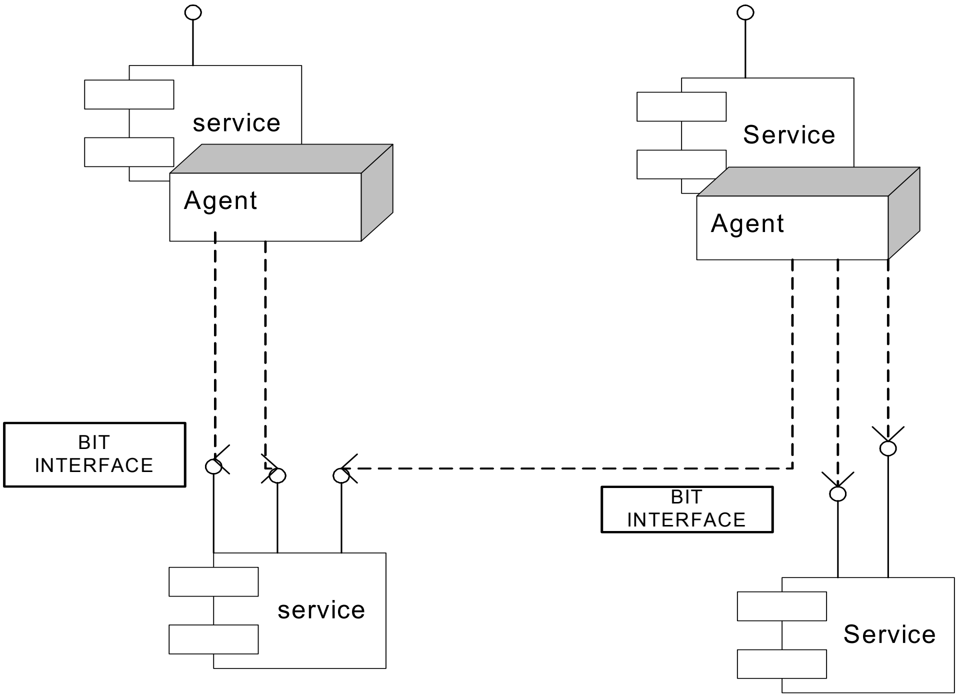

Figure 2. System architecture.

The services model was designed to be a more appropriate approach to building integrated solutions. Using services as described here provides you with the following benefits:

- Independent management. This means that you can move or duplicate your services with no adverse effects on the system. Duplication of services allows you to scale out.
- Technology independence between consumer and provider. Interoperability is improved, enabling diverse systems to easily communicate and share information.
- Separation of functional and operational requirements. The operational aspects of the service are dealt with by the infrastructure and the core business functionality is contained in the service. This makes the functional and operational requirements orthogonal to each other, meaning that different people, or even departments, can work on the separate parts.
- Standards based. Services are based on the use of standards-based technologies such as SOAP, HTTP, and XML. This means that you are not limited to using only one vendor's products.

The services-based architecture provides a model for software that is designed for integration and designed for change.

4.3.4 Balanced scorecard in education

E-learning systems are often not addressing fundamental strategic objectives and are not being rigorously evaluated. E-learning system is being approached as a technical solution rather than a business solution.

In our project we handle the e-learning system as a powerful solution for achieving strategic objectives of the University and measure the impact of the system implementation on the performance of the University both in monetary and non-monetary way.

The overall aim of the University is to be the most attractive and successful educational and scientific institution. To achieve this aim the University should attain the following objectives:

1. To have outstanding academic personnel;

2. To perform high-level scientific research work
3. To establish efficient, innovative and appealing studying/training process;
4. To have talented students and community support;
5. To use University resources in most effective and efficient way.

For measuring the e-learning system's performance and its influence on the overall performance of the organization we use Balanced Scorecard Approach, which aligns e-learning system to organization's strategy and its key objectives, and measures performance. The approach was developed in the 1990's by Drs. Robert Kaplan and David Norton (1996). The balanced scorecard suggests that we view the organization from four perspectives and measure organizational performance in four key areas: (1) Finance, (2) Customers, (3) Business Processes, (4) Learning and Innovation. For the University as a non-profit organization we translate traditional dimensions as follows: (1) Resource Management, (2) Constituents, (3) Academic and Support Processes, (4) People and Technology.

Cause and effect relationships for the University organization

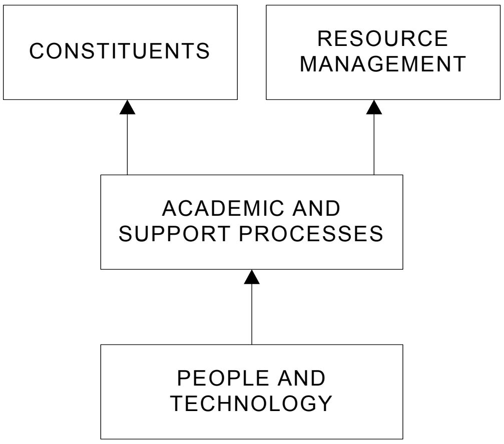

Figure 2. Cause and effect relationships for the University organization

4.3.5 BSC for adaptive e-learning system

INITIATIVE: IMPLEMENT ADAPTIVE E-LEARNING SYSTEM

BSC perspective / BSC category	MAIN OBJECTIVES	KEY MEASURES	YEAR 2006 TARGETS
RESOURCE MANAGEMENT	Efficient, effective and transparent use of budget resources	TCO	TCO decline by 20%
CONSTITUENTS	Better access to learning; high academic achievements and quality	Constituents satisfaction with learning consistency; retention rates	Satisfaction rise 50%; retention rates rise 25-60%
ACADEMIC AND SUPPORT PROCESSES	Efficient and effective processes	Studying process performance, training process time	Performance improvement by 10-15%; training time saved 35-45%
PEOPLE AND TECHNOLOGY	Standard-based, language/platform independent solutions. Competent personnel.	Flexibility, standards support, ease of integration, manageability, BPM functionality of the e-learning system. E-learning system usage rate.	E-learning system implemented 01.01.06. 80% of personnel use e-learning system.

According to the BSC methodology the impact of the implementing any information system (here: adaptive e-learning system) on the University performance can be measured in four different ways: (1) IT system quality improvement (i.e. ISO 9126); (2) academic and support processes' efficiency and effectiveness improvement, (3) growth of constituents satisfaction; (4) better cost performance.

The main benefits to be achieved by implementing the adaptive e-learning system at the University are as follows.

People and technology perspective

The overall objective in this perspective is to build open standards-based, language/platform independent modern IT solutions, which are easy to develop and maintain, able no only to support academic and support processes, but also drive process change, and which do not need narrowly specialized IT stuff. Here we measure broadness of functionality (incl. business process management, BPM), ease of integration, standards support, flexibility, performance of the solution. Adaptive E-learning system based on web services and software agents is characterized by ease of integration, flexibility, manageability, standards support and built-in functionality of BPM.

To implement the e-learning system academic personnel must be educated in e-learning skills. For the year 2006 we have the target of ***80%*** of academic personnel to use e-learning system. To achieve the target user manuals must be ready and training done by the beginning of January, 2006.

Process perspective

The strategic objective for us in process perspective is to maximize the efficiency, effectiveness and quality of academic and support processes in the organization. For academic processes we expect the following benefits from e-learning system implementation:

- training process effectiveness: relative to full instructor-led training adaptive e-learning saves 35-45% in training time;
- studying process quality: performance increase by 10-15%.

Constituents perspective

By implementing the e-learning system we intend to improve first and foremost the access to learning, which will call forth the rise of retention rates.

The targets set for 2006 are:

- retention rates rise 25-60%;
- satisfaction with learning consistency increases by 50%.

The academic achievements and quality will be measured by number of articles and citation index. Because of more effective resource distribution between training and scientific research, and better quality of studying process achieved by implementation of the e-learning system we predict some impact of the e-learning system implementation on this indicator. However, due to the long-term nature of this relationship, no targets are set for this indicator for the year 2006.

Resource management perspective

In this perspective we want to achieve the maximum efficiency of the budget resources in use. Within this perspective of BSC we calculate TCO of e-learning system .

TCO is a concept by which all costs associated with a capital investment are accounted. There are broadly speaking two different types of assets: firstly, the development and execution environment required for developing and executing web services, and secondly the web service itself. We calculate a TCO for both asset types.

We assume, according to cause and effect relationships, that there are mainly three factors that drive TCO:

1. technology;
2. people;
3. processes.

In our TCO model we include the following costs:

- cost of knowledge (IT stuff training and consulting);
- cost of infrastructure;
- cost of the development process: design of the web service, implementation, test, deployment,
- network cost, as XML traffic is heavier than binary traffic;
- cost to make web service public;
- cost of maintenance, which consists of systems and personnel costs derived from Activity Based Costing (ABC) model.

In the resource management perspective we set the target of TCO reduce by 20%.

4.3.6 Instructional support system architecture

Agent-based instructional support system guides the instructional process to treat each student individually. Each course includes number of tests; each test consists of groups of questions. Related to each question is a paragraph of the course instructional material. According to the student answers to the diagnostic test questions system offers to the student right paragraph of the course instructional material or the prerequisite course material. The system provides continuous reporting of progress.

4.3.7 Decision support component

Our goal is to find best web service among multiple offerings. Business can advertise their offerings in UDDI (2004) registry servers. Since these registries have straight access methods (i.e. the find service and get_serviceDetail methods), a intelligent mechanisms can be developed for their analysis. Decision support component represent a possible solution for the problem. In this component the multi-criteria analysis methods are implemented. In this approach, we consider service execution statistics, service availability statistics and consumer preferences as input for the multi-criteria analysis techniques.

An overview of multi-criteria analysis techniques

Multi-criteria analysis –MCA (DTLR multi-criteria analysis manual. (2001), Saaty (1994)) establishes preferences between options by reference to an explicit set of objectives that the decision making body has identified, and for which it has established measurable criteria to assess the extent to which the objectives have been achieved. In simple circumstances, the process of identifying objectives and criteria may alone provide enough information for decision-makers. MCA offers a number of ways of aggregating the data on individual criteria to provide indicators of the overall performance of options.
A standard feature of multi-criteria analysis is a performance matrix, or consequence table, in which each row describes an option and each column describes the performance of the options against each criterion. The individual performance assessments are often numerical, but may also be expressed as 'bullet point' scores, or colour coding.
MCA techniques commonly apply numerical analysis to a performance matrix in two stages:

1. Scoring: the expected consequences of each option are assigned a numerical score on a strength of preference scale for each option for each criterion. More preferred options score higher on the scale, and less preferred options score lower. In practice, scales extending from 0 to 100 are often used, where 0 represents a real or hypothetical least preferred option, and 100 is associated with a real or hypothetical most preferred option. All options considered in the MCA would then fall between 0 and 100.
2. Weighting: numerical weights are assigned to define, for each criterion, the relative valuations of a shift between the top and bottom of the chosen scale.

In this project we implement three groups of methods for multi-criteria analysis:

- Linear additive model
- The Analytical Hierarchy Process
- Outranking methods

Linear additive model

If it can either be proved, or reasonably assumed, that the criteria are preferentially independent of each other and if uncertainty is not formally built into the MCA model, then the simple linear additive evaluation model is applicable [10]. The linear model shows how an option's values on the many criteria can be combined into one overall value. This is done by multiplying the value score on each criterion by the weight of that criterion, and then adding all those weighted scores together. Models of this type have a well-established record of providing robust and effective support to decision-makers working on a range of problems and in various circumstances.

The Analytical Hierarchy Process

The Analytic Hierarchy Process (AHP) Saaty (1994) also develops a linear additive model, but, in its standard format, uses procedures for deriving the weights and the scores achieved by alternatives which are based, respectively, on pair wise comparisons between criteria and between options. Thus, for example, in assessing weights, the decision maker is asked a series of questions, each of which asks how important one particular criterion is relative to another for the decision being addressed. The strengths and weaknesses of the AHP have been the subject of substantial debate among specialists in MCA. It is clear that users generally find the pair wise comparison form of data input straightforward and convenient. On the other hand, serious doubts have been raised about the theoretical foundations of the AHP and about some of its properties. In particular, the rank reversal phenomenon has caused concern This is the possibility that, simply by adding another option to the list of options being evaluated, the ranking of two other options, not related in any way to the new one, can be reversed. This is seen by many as inconsistent with rational evaluation of options and thus questions the underlying theoretical basis of the AHP.

Outranking method

A rather different approach from any of those discussed so far has been developed in France Keefer et al (2002) and has achieved a fair degree of application in some continental European countries. It depends upon the concept of outranking. The methods that have evolved all use outranking to seek to eliminate alternatives that are, in a particular sense, 'dominated'. Dominance within the outranking frame of reference uses weights to give more influence to some criteria than others. One option is said to outrank another if it outperforms the other on enough criteria of sufficient importance (as reflected by the sum of the criteria weights) and is not outperformed by the other option in the sense of recording a significantly inferior performance on any one criterion. All options are then assessed in terms of the extent to which they exhibit sufficient outranking with respect to the full set of options being considered as measured against a pair of threshold parameters.
The main concern voiced about the outranking approach is that it is dependent on some rather arbitrary definitions of what precisely constitutes outranking and how the threshold parameters are set and later manipulated by the decision maker.

Multi-criteria analysis usage example

Agent-based instructional support system guides the instructional process to treat each student individually. Each course includes number of tests; each test consists of groups of questions. Related to each question is a paragraph of the course instructional material. According to the student answers to the diagnostic test questions system offers to the student right paragraph of the course instructional material or the prerequisite course material. The system provides continuous reporting of progress.

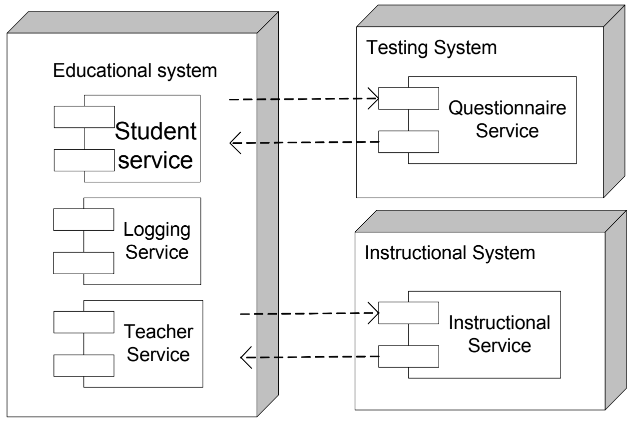

Figure 3. Instructional testing system deployment diagram

In system many services interact with each other: questionnaire service, instructional service, test analysis service, teacher service, logging service and student service. The information agent manages these interactions.

Steps of multi-criteria analysis

A full application of multi-criteria analysis normally involves seven steps:

- Identify the options.
- Identify the objectives and criteria that reflect the value associated with the consequences of each option.
- Describe the expected performance of each option against the criteria.
- Weighting. Assign weights for each of the criteria to reflect their relative importance to the decision.
- Combine the weights and scores for each of the options to derive and overall value.
- Examine the results.

The performance matrix

A standard feature of multi-criteria analysis is a *performance matrix*, or consequence table, in which each row describes an option and each column describes the performance of the options against each criterion. The individual performance assessments are often numerical, measured in ordinal, interval or ratio scale.

A mathematical definition of ordinal is: can be transformed by any increasing monotonic function. Ordinal numbers are sometimes referred to as rank numbers.

A mathematical definition of interval is: can be subjected to a linear transformation, or is invariant under the transformation $Y = a X + b$.

A mathematical definition of ratio is: admits multiplication by a constant, or is invariant under the transformation $Y = a X$. A ratio scale is said to have a true 'zero', however the true zero can be conceptual and need not be observable.

Table 1

Classifier	**Item Type**	**Language**	**Primary audience**
All/Business/ Information	LOM	English	High school

Systems			

Options	Peer rev.	Com-ments avg.	Assign-ments	Col-lec-tions	Avail-ability
Managing the Digital Enterprise	5.0	0	0	22	100
Computer literacy	5.0	4.3	0	17	83
HTML interactive tutorial	5.0	5.0	0	3	95
ERP Central	4.6	0	0	2	94
Relational Databases	3.3	0	0	3	87
Web monkey	0	4.0	3	1	100
ER modelling	0	4.0	0	2	100

Table 1 shows a simple example of performance matrix. The table shows the performance of a number of different learning materials in regard to a set of criteria thought to be relevant in a student agent choice between different options. These criteria are peer review average, member comments average, the number of assignments, personal collections where learning material can be found, availability statistics.
In a basic form of MCA this performance matrix may be the final product of the analysis. The decision makers are then left with the task of assessing the extent to which their objectives are met by the entries in the matrix. In analytically more sophisticated MCA techniques the information in the basic matrix is usually converted into consistent numerical values.

Scoring and weighting

At this point a problem arises. It isn't possible to combine money, ticks, stars and ratings to achieve an overall evaluation of the options.
MCA techniques commonly apply numerical analysis to a performance matrix in two stages:

1. Scoring: the expected consequences of each option are assigned a numerical score on a strength of preference scale for each option for each criterion. More preferred options score higher on the scale, and less preferred options score lower. In practice, scales extending from 0 to 100 are often used, where 0 represents a real or hypothetical least

preferred option, and 100 is associated with a real or hypothetical most preferred option. All options considered in the MCA would then fall between 0 and 100.

2. Weighting: numerical weights are assigned to define, for each criterion, the relative valuations of a shift between the top and bottom of the chosen scale. Mathematical routines, then combine these two components to give an overall assessment of each option being appraised. This approach therefore requires individuals to provide those inputs that they are best suited to provide, and leaves

The overall preference score for each option is simply the weighted average of its scores on all the criteria. Letting the preference score for option i on criterion j be represented by sij and the weight for each criterion by wj, then for criteria the overall score for each option, Si, is given by:

$$S_i = w_1 s_{i1} + w_2 s_{i2} + \ldots + w_n s_{in} = \sum_{j=1}^{n} w_j s_{ij}$$

In words, multiply an option's score on a criterion by the importance weight of the criterion, do that for all the criteria, then sum the products to give the overall preference score for that option. Then repeat the process for the remaining options.

Table 2 Weights

Options	**Peer rev.**	**Com-ments avg.**	**Assig n-ments**	**Col-lec-tion**	**Avail-ability**
	0.3	0.2	0.1	0.2	0.2

Table 3 Scored

Options	**Peer rev.**	**Commentavg.**	**As-sign-ment**	**Collection**	**AVAIL**	**SCORE**
Managing the Digital Enterprise	100	0	0	100	100	70
Computer literacy	100	86	0	77,3	83	79,26
HTML interactive tutorial	100	100	0	13,6	95	71,72
ERP	92	0	0	9,1	94	48,2

Central						2
Relational Databases	66	0	0	13,6	87	39,92
Web monkey	0	80	100	4,6	100	46,92
ER modelling	0	80	0	9,1	100	37,82

The basic AHP procedure

At the core of the Analytic Hierarchy Process (AHP) lies a method for converting subjective assessments of relative importance to a set of overall scores or weights. The method was originally devised by Saaty[15]. It has proved to be one of the more widely applied MCA methods. However, at the same time, it has attracted substantial criticism from a number of MCA specialists. There have also been attempts to derive similar methods that retain the strengths of AHP while avoiding some of the criticisms.
The fundamental input to the AHP is the decision maker's answers to a series of questions of the general form, 'How important is criterion *A* relative to criterion *B*?'. These are termed pairwise comparisons. Questions of this type may be used to establish, within AHP, both weights for criteria and performance scores for options on the different criteria.
Consider firstly the derivation of weights. It is assumed that a set of criteria has already been established, as discussed in 1.3. For each pair of criteria, the decision-maker is then required to respond to a pairwise comparison question asking the relative importance of the two.
Responses are gathered in verbal form and subsequently codified on a nine-point intensity scale, as follows:

- Equally important – 1
- Moderately more important – 3
- Strongly more important – 5
- Very strongly more important – 7
- Overwhelmingly more important -9

2, 4, 6 and 8 are intermediate values that can be used to represent shades of judgment between the five basic assessments.
If the judgment is that *B* is more important than *A*, then the reciprocal of the relevant index value is assigned. For example, if *B* is felt to be very strongly more important as a criterion for the decision than *A*, then the value 1/7 would be assigned to *A* relative to *B*. Because the decision maker is assumed to be consistent in making judgments about any one pair of criteria and since all criteria will always rank equally when compared to themselves, it is only ever necessary to make $1/2n(n - 1)$ comparisons to establish the full set of pairwise judgments for n criteria. Thus a typical matrix for establishing the relative importance of three criteria might look like:

$$\begin{matrix} 1 & 5 & 9 \\ 1/5 & 1 & 3 \\ 1/9 & 1/3 & 1 \end{matrix}$$

The next step is to estimate the set of weights (three in the above example) that are most consistent with the relativities expressed in the matrix. Note that while there is complete consistency in the (reciprocal) judgments made about any one pair, consistency of judgments **between** pairs is not guaranteed. Thus the task is to search for the three w_j will provide the best fit to the 'observations' recorded in the pairwise comparison matrix. This may be done in a number of ways.

Saaty's basic method to identify the value of the weights depends on relatively advanced ideas in matrix algebra and calculates the weights as the elements in the eigenvector associated with the maximum eigenvalue of the matrix. For the above set of pairwise comparisons, the resulting weights are:

$w1 = 0.751$ $w2 = 0.178$ $w3 = 0.070$.

In addition to calculating weights for the criteria in this way, full implementation of the AHP also uses pairwise comparison to establish relative performance scores for each of the options on each criterion. In this case, the series of pairwise questions to be answered asks about the relative importance of the performances of pairs of alternatives in terms of their contribution towards fulfilling each criterion. Responses use the same set of nine index assessments as before. If there are *m* options and *n* criteria, then *n* separate *m* X *m* matrices must be created and processed.

The proposed methodology provides component-based extensibility, allowing to manage educational information systems. It provides web services and agent based connections for integrating functional subsystems. The XML, WSDL and SOAP are the communication vehicles for the functional systems. The methodology is used to create the educational system for Estonian Business School and successfully explored a college year. BIT technology is tested as part of EU project IST-1999-20162. The simplified integration promised by Web services poses some potentially drastic changes for IT departments. Not all of these changes can be so easily managed. Let us try to analyze some pros and cons of this solution.

Pro: The potential for cost savings with an out-of-box interoperable solution can be considerable. After some of the major implementation debacles of the last few years, most companies understand the value of a short implementation time.

Pro: The interoperability across platforms, applications, and programming languages is the second positive feature of the methodology.

Con: Web services require a rethinking of systems - if not a redesign. For enterprises to succeed at Web services, they need to embrace the concept of SODA (services-oriented development of applications). SODA requires developers to work with dynamic modules of services rather than static code.

Most BSC risks and problems are not of technical but organizational character.

The project is not supported enough by top management of the organization. The main cause of the problem is unclear relation between project objectives and organization performance. To cope with this risk the objectives and targets of the project must be aligned with organization strategies and BSC.

Influence of the new system implementation on process performance is not clear enough. Organization's performance indicators, performance monitoring and measuring techniques must be defined clearly, process owners must be assigned to every process.
Measurement of monetary benefits of the project (cost reduction) is complicated. Accounting system must be mature enough to perform TCO evaluation and activity based costing.

References:

Allen, P. (2001), Realizing e-Business with Components. Addison_Wesley, Pearson Education Limited.

Afuah, A., Tucci, C.L. (2001), Internet Business Models and Strategies: Text and Cases. McGraw-Hill Higher Education.

Brown,, J.S., Collins, A., & Duguid, P. (1989) Situated cognition and the culture of learning. Educational Researcher, 18(1), 32-41.

Brooks, D.G. and Kirkwood, C.W. (1988), 'Decision analysis to select a microcomputer networking strategy: a procedure and a case study', *Journal of the Operational Research Society,* 39, pp.23-32.).

Chappel, D.A., Chopra, V., Dubray J.J, E. Colleen, B. Harvey, T. McGrath, D. Nickull, M. Noordzij, B. Peat, Pim van der Eijk, J. Vega, (2001), Professional ebXML Foundations. Wrox Press Ltd..

Devedzic, V. (2000), Inside Intelligent Tutoring Systems - Using Design Patterns", International Journal of Knowledge-Based Intelligent Engineering Systems, Vol.4, No.1, January 2000, pp. 25-32.

DTLR multi-criteria analysis manual. (2001), On www January 2004
www.odpm.gov.uk/stellent/groups/odpm_about/documents/pdf/odpm_about_pdf_608524.pdf

Duval Erik. (2003), **Learning Objects & ARIADNE – *advanced* learning.** ICALT2003 - 3rd IEEE International Conference on Advanced Learning Technologies, 9-11 July 2003, Athens, Greece, keynote presentation. On www march 2003.
http://www.cs.kuleuven.ac.be/~erikd/PRES/Recent.html

Gagne, R. (1985). The conditions of learning. New York. Holt, Rinehart and Winston.

Gardner H. (1993), Frames of Mind: The Theory of Multiple Intelligences.

Greeno, J. G., Collins A. M., & Resnick, L. B. (1996). Cognition and learning. In D. Berliner & R. Calfee (Eds.), Handbook of educational psychology (pp. 15-46). New York, NY: Simon & Schuster Macmillan.

IMS Global Learning consortsium. (2000), IMS Question & Test interoperability Specification: A Review.

Kaplan R. S., D. P. Norton. (1996), The Balanced Scorecard. From Strategy to Action. Harvard Business School Press.

Keefer, D. L., Kirkwood C. W., Corner J.L. (2002), Summary of Decision Analysis Applications in the Operations Research Literature. 1990-2001. Department of Supply Chain Management, Arizona State University, Tempe, AZ.

Kolb, D. (1998), Experiential Learning: Experience as the Source of Learning and Development.

Lave, J. and Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge: Cambridge University Press.

Mason A., Wanagel J., Khaund S., Smith S., Corbisier R., C. Stanos C. (2003), Building Interoperable Web Services using the WS-I Basic Profile 1.0.

McCarthy B. (1987), The 4-MAT System: Teaching to Learning Styles with Right/Left Mode Techniques.

Newell, A. (1990), Unified Theories of Cognition, Cambridge, MA: Harvard University Press
Anderson, J.R. (1993). *Rules of the Mind*. Hillsdale, NJ: Erlbaum.

Novak J. D. (2005), The Theory Underlying Concept Maps and How To Construct Them. Cornell University. http://cmap.coginst.uwf.edu/info/ 10.nov 2005.

Reigeluth C. M., Editor. (1999), Instructional-Design Theories and Models. Volume II. Mahwah, NJ: Lawrence Erlbaum Associates.

Resnick, L.B. & Resnick, D.P. (1991), Assessing the thinking curriculum: New tools for education reform. In B.R. Gifford & M.C. O'Connor (Eds) Changing assessment: Alternative views of aptitude, achievement and instruction. Boston: Kluwer.

Roy, B. and Vanderpooten, D. (1996), "The European School of MCDA: emergence, basic features and current works", *Journal of Multi-Criteria Decision Analysis,* 5, pp.22-37.

Saaty, T.L. (1994), *Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process*, RWS Publications, Pittsburgh, PA.

Terry Mayes, Sara de Freitas. (2001). JISC e-Learning Models Desk Study. http://www.jisc.ac.uk/uploaded_documents/Stage%202%20Learning%20Models%20(Version%201).pdf 09. november 2005.

UDDI (2004) http://www.uddi.org.

Vygotsky, L.S. (1978). *Mind in Society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Wilson, B.G. & Myers, K.M. (2000), Situated Cognition in Theoretical and Practical Context. In In D.H. Jonassen, & S.M.Land(eds), Theoretical Foundations of Learning Environments. NJ: Lawrence Erlbaum.