e-ducation

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Abstract

e-ducation is a study of information technology use in higher education. The aim of the research is to improve educational practice with information technology. The modern educational system was developed to teach the students the skills necessary and the facts applicable to survive in the industrial society; facts that would be true and skills that would be useful throughout their entire life. Today, schools need to help students develop conceptual tools to be self directed learners capable of learning new things and adopt to an increasingly dynamic, and also complex, work situation. Many educators believe in the immense potential of information technology as learning tools, but for the information technology to bring about a real and substantial change, its introduction must be accompanied by improvements in our understanding of learning and teaching.

The research approach applied has been a "design oriented study of information technology use with the intention to contribute to the development of both the use and the technology itself." This has been done through action research and experiments in educational settings. The thesis consists of six papers and an introduction.

The main results in this research are the following four: (1) The e-ducation framework which can be used to understand important current trends in education. (2) The PIE approach (problem based learning, interactive multimedia and experiential learning), developed to enhance the problem based learning methodology. (3) The philosophy of Thematic Modules (TM), developed to structure collaborative educational activities in information technology based environments, such as asynchronous learning networks (ALN). (4) Concrete examples of alternative forms of computer supported assessment of learning and examination.

Keywords
information technology, education, teaching, learning, constructivism, problem based learning.

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Preface

e-ducation is a study of information technology use in higher education. It is a study slightly more inspired by technology push than by pedagogical pull. The aim of the research is to develop ideas for how to use information technology (IT) to support learning in higher education in pedagogically well-grounded ways. The work is influenced by a changing view of teaching and learning in the university context, from a factory metaphor with a well-regulated production line to a market-place bustling with interaction and negotiation among all actors.

e-ducation is an example of how work becomes research. Teaching and coordinating university courses for a number of years, I came to realize that the traditional teaching approach had to give way for new approaches. The research has been conducted in a turbulent time in what many people consider to be a social revolution. Whereas some of this talk of revolution is mainly rhetorical, the changes actually have large impact on the education system. Educational institutions clearly have a different situation today with more students, less funding and changing educational goals. Politicians, school leaders, curriculum designers and individual teachers are trying to adapt to the new situation that is emerging.

Today's IT revolution is also an education revolution. The motivation behind this thesis is a desire to play a role in this educational revolution. The complex educational situation we are facing today is described and conceptualized. It involves both new and user unfriendly technology and deep questions of teaching and learning. I believe the problems we have with technology are temporary, and that the specific problems we are experiencing at the moment will soon be replaced by others. I also believe that the questions we ask about learning and teaching are of a classical nature and will be on the research agenda for a long time. The underlying message throughout the thesis is: when we are building electronic learning environments in higher education we should not aim at replicating the old practices with new tools but instead actually create new cultures of learning in which tradition and new approaches meet.

The thesis consists of an introduction and six papers that have been published in journals and conference proceedings, or are currently in the process of being published. The modular nature of my research has made possible joint projects with other researchers as well as an opportunity to let the thesis develop in manageable parts—one by one, but also concurrently.

The six papers investigate different aspects of higher education teaching and learning, and give proposals for how these aspects can be approached with information technology. The research documented in the thesis is pluralistic, in a conceptual as well as a methodological sense. My research is both descriptive and normative.

In my work I have strived for originality, credibility and communicability. Let me briefly discuss these three properties in the light of my thesis.

- **Originality. The research documented in the thesis deals with both classical as well as situational and immediate problems in higher education.**
- **Credibility. Since my research is of an action research nature with myself in the core of the action a critical relation to the collected data is necessary.**
- **Communicability. The fact that the dissertation consists of separate, but related papers, increases, I believe, its communicative force.**

The primary contribution of this research is that it gives concrete examples of how to use information technology in a well-grounded pedagogical way, but the thesis also provides knowledge that will inform the design of information technology use in higher education.

Being a Ph.D. candidate is much like being on a journey, entering a number of smoggy cities in the middle of the night, getting a first impression, going to bed and waking up ready to rethink this first impression. Thus, during most of the dissertation process one thing has been very clear to me. A dissertation is an exercise in research. This way, it is the process of learning how to conduct research, so that the scholar may continue to uncover or produce further knowledge after the graduate days are over. It took me some time to realize that research is more than good ideas; that most of all it is many hours of struggling and hard work. For a full list of the research papers I have been involved in during my Ph.D. studies please see Appendix 1.

Acknowledgements

Although a project such as this seems to take forever to complete, this dissertation was completed in a finite amount of time. This accomplishment is due in large part to the support and advice I received

from many people throughout the journey. During my dissertation project several persons have been of invaluable help. I would like to distinguish three, partly overlapping, groups—seniors, juniors and my family—whom in their special way have contributed to the research and the completion of the thesis. Please forgive me if I have forgotten to mention any of you. First, I am very grateful to my supervisor Bo Dahlbom who has supported me through the whole process. Second, I would like to thank my co-author Helana Scheepers, with whom it has been very stimulating to work with. Thanks also to: Fredrik Ljungberg, Kalevi Pessi, Agneta Ranerup, Thanos Magoulas, Lars Mathiassen, Ove Jobring, Christian Hardless, Per Åsberg, Daniel Bjarsch, Erik Finnman, Ola Svensson, Joachim Malm, Pontus Nuldén, and all the students who have participated in the experiments and in my courses were I have tried different ideas. Finally my four girls: Lisa, Celia, Nadia and Karen for their support and patience.

Göteborg, May 1999

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Contents

Introduction

First Paper

Second Paper

Third Paper

Fourth Paper

Fifth Paper

Sixth paper

Introduction

e-ducation: A Framework for Research and Practice

Urban Nuldén

Abstract

This is an introduction to the six papers that constitute the substance of this thesis. In this section I describe the context of the research, the aim of the research, the theoretical and technological background, the research approach, the six papers, and finally I summarize the results and implications, and outline further research.

1. Problems in Education

The modern educational system was developed to teach the students the skills necessary and the facts applicable to survive in the industrial society; facts that would be true and skills that would be useful throughout their entire life. The factory was the model of choice; all students learned the same way and should learn the same things; all should be at the same place at the same time; and facts were transmitted to the students and later measured through instruments like written exams. But things have changed: "Schools today are structured more for the industrial age … problem is, those factory jobs don't exist anymore" (Soloway 1993, p.28).

While the most important objective of schools and education used to be the teaching of facts and skills, today there is an intention among many educators to put equal importance on the actual process of acquiring the knowledge as on the knowledge itself. Education needs to help students develop conceptual tools to be self directed learners capable of learning new things and adopt to an increasingly dynamic, and also complex, work situation. Education has changed from teaching to learning with a change of roles and responsibilities in the learning process. I will elaborate this further later in this section. However, there is another element, which is entering education.

Computers are now so commonplace in educational institutions that their absence is more noteworthy than their presence (Bigum 1998, p.587). Computers or rather information technology (IT) have become a routine component of many aspects of education. Information technology use in education is framed by the teachers beliefs about computers and reflected in the day-to-day educational practices. Many educators believe in the immense potential of computers as learning tools. But for the computer to bring about a real and substantial change, its introduction must be accompanied by improvements in our understanding of learning and teaching.

The area of educational technology and pedagogic is full of jargon, confusion and lack of organization. Various models and frameworks have been proposed to give some organization to the field (e.g., Ramsden 1992; Laurillard 1993; Leidner and Jarvenpaa 1993; Harasim, Hiltz et al. 1995; Leidner and Jarvenpaa 1995; Duffy and Cunningham 1996). These, and many others, provide guidelines for how information technology can be introduced and used to improve the teaching and learning processes in

higher education. Clearly, in the absence of fundamental changes to the teaching and learning process, information technology will do little but speed up ineffective processes and methods of teaching.

This thesis is a contribution to educational practice. During the last three years I have conducted action research with myself very much at the core of the action. I have performed a series of experiments and the thesis is reporting on them. Institutions in higher education need to provide a supportive climate in which educators and researchers can work together to determine the effectiveness of different methods of teaching, learning, and assessment in practice. Many of us are already engaged in this effort, but I would like to give this work a higher priority. In particular, I would like to see more effective transfer of individual experience to a wider group of educators.

Schools have remained fairly unchanged throughout this century. Today, there is a growing consensus that the underlying mission of education can neither remain the indoctrination of knowledge and skills, values and behavior, nor the transmission of information and authority. Enthusiasts in the education system bring forward new ideas about pedagogy and educational technology. However, it is obvious that teachers are well adapted to a particular niche and it is understandable that their first response to attempts at change is one of resistance. The norms of the teacher culture are profoundly conservative and teachers' resistance to change plays an important role in shaping their response to both pedagogical and technological innovation. For years educators have tried to reform the system, yet many have reached a point where the enormity of the task results in abandonment of the ideas. Over time the idealism and enthusiasm of the novice teacher will fade away.

Today the culture of the educational system is challenged. Information technology has the power of being both a catalyst and a main vehicle for implementing change and may help to bring about some important reforms (Barker and Dickson 1996). But still, information technology is used just as any other educational technology for fact or information transfer. If we continue to re-implement conventional models from the classroom with teacher centered activities focusing transmitting information to passive learners, we can expect only marginal improvement of the quality in our teaching, if any improvement at all. Just providing schools with an infrastructure, i.e. computers and networks, will

not have the desired effect. This push action may actually result in a continuation of the technology rejection. Teachers will begin the process of 'pull' when they know for what, why and how technology should be used. Today many educators have no idea where to begin and what to do with this technology.

A large number of teachers are confronted with new pedagogical principles as well as new technology. It is not easy to switch to a different mode of teaching for those with years of experience of a traditional form of teaching. Many teachers tend to think that they are more important to the learning process than they actually are (Schank 1997, p.46). For them the view of the authority or the professional as the ultimate source of all knowledge is threatened.

1.1. Researching Education

The theoretical foundation for this research is to a large extent *pedagogy* (the science of education), *didactic* (the science of teaching), and theories of learning. The relations and distinctions among the concepts are not clear-cut (Kroksmark 1995, p.366). However, this is not explicitly discussed in this dissertation; instead I have adopted a more instrumental standpoint in a few concepts concerning education. Namely: constructivism, collaborative learning, problem based learning, experiential learning and formative assessment of learning.

The methodological and practical guidelines in this research originate from informatics, which is the "design oriented study of information technology use with the intention to contribute to the development of both the use and the technology itself" (Dahlbom 1996). New use domains, in all fields, are constantly made possible by advances in computing and the central interest of informatics is to intervene and contribute to the process of change rather than just to observe and describe it. Information technology changes people's work [and learning] and our interest is to augment their skills by the technology rather than to replace them with information technology (Ehn 1988, p.373).

The research reported in this thesis has approached classical, situational and immediate concerns in the field of information technology and education. This taxonomy was suggested by Peter Keen in his keynote address at the 6th European Conference on Information Systems (ECIS) in Aix-en-Provence, France, June 1998. According to Keen, classical concerns are eternal questions; situational concerns are questions

important for their time; and immediate concerns are those we have to solve before moving on. The box below summarizes this thesis in relation to the three concerns.

Classical	**There is an ongoing discussion about learning, and there are competing theories of learning. How can we contribute to this body of research about the process of learning? How can we improve learning?**
Situational	**The World Wide Web (WWW) and the Internet are maturing and becoming a platform for development of educational applications. What are the possibilities using the World Wide Web and the Internet as educational technologies?**
Immediate	**Many educators are frustrated by information technology in education. Information technology has entered the educational system as a stranger. The first reaction is to try to push it out. The next reaction is to adapt it to traditional models of teaching. How can we find fruitful ways to discuss and develop innovative use of information technology in education?**

Box 1: What are the Concerns of the Research?

2. Theoretical Background

This section discusses the educational theories and ideas that are central to this research. I have been working as a teacher of informatics for a number of years. During this time some educational theories and ideas have come to influence my understanding of education and the learning process more than others. The ideas are my grounding assumptions, i.e., "the fundamental assumptions underlying our conception of the teaching-learning process" (Duffy and Cunningham 1996). These pedagogical ideas have also inspired me to use information technology to take the ideas further. These ideas are: First, the understanding of learning as individual construction of knowledge, i.e., constructivism. Second, the insight how both individual learning and collective learning can be supported by the group, i.e., collaborative learning. Third, problem based learning as a model

for designing educational activities. Fourth, experiential learning to initiate learning activities. And fifth, the notion of formative assessment as an alternative to summative examination. These five ideas are further discussed later in this section.

A common interpretation is that "pedagogy" is the science of education and "didactic" is the science of teaching. The relations and distinctions among the concepts of education, teaching and learning are not, however, clear-cut (Kroksmark 1995, p.366), and there are several competing conceptualizations. In this research I have adopted an instrumental standpoint in relation to the concepts of education and teaching. The concept of education is used to cover the complex processes of teaching and learning, and teaching is understood as all the different tasks carried out by the teacher.

Everyone who teaches has some theory of learning. A learning theory is a systematic and integrated understanding of the process whereby people relate to their environment in such way as to enhance their abilities to employ both themselves and their environment effectively (Bigge and Shermis 1999, p.3). Educators may, or may not, be able to describe their theories in explicit terms, but their practice is always exemplifying a theory of learning. The ways in which the educator designs and conducts learning activities reveals how the educator understands the process of learning (Kaplan and Kies 1995). The teacher's own learning style is also influencing how the educational activities are designed.

There are different ways of going about learning. These different ways are also referred to as learning strategies, cognitive strategies, study habits or approaches to studying (Naidu 1994, p.26). Rigney suggests that learning strategies can be considered as either designer imposed, i.e., the teacher expects a certain behavior, or learner generated (Rigney 1978). Kolb proposes four different learning styles—assimilator, diverger, converger, and accommodator—that will influence the design of educational activities (Kolb 1985).

However, an individual teacher's theory of learning may be inconsistent. Some teachers use a hodge-podge of methods without the slightest theoretical orientation. This means that educators often adapt features from a variety of theories about learning without recognizing the conflicting assumptions hidden in the features.

2.1. Constructivistic learning

A variety of models are used to characterize different paradigms of learning. Simplifying a bit, learning theories can be classified as either behavioral or cognitive. The behavioral models are based on Skinner's objectivist theory of learning as conditioning (Skinner 1968), while the cognitive models view learning as individual knowledge construction and more recently as involving collaboration. The collaborative aspects are discussed further in the next section.

Traditionally, the model of choice in education has been the objectivist model of learning, e.g., the lecture method (e.g., Leidner and Jarvenpaa 1995, p.267). Basically, facts and information exist out there and the instructor acts as an intermediary who filters, selects and transmits the information to ignorant students. The dominating activity is active teachers presenting information to passive students, through lectures, and written material, such as textbooks. Students then provide the teacher with evidence of learning by recitation; orally or in written exams. The overall objective for the teacher is to produce, in the mind of the student, the necessary body of knowledge.

The objectivist model is criticized for stimulating surface learning (O'Neil 1995), knowledge reproduction and be one of knowledge telling (Schank 1997), instead of knowledge building (Scardamalia and Bereiter 1993, p.37). Knowledge building is based on a constructivist/social cognitive world view where knowledge is constructed as it fits the individual's experience of the world (Harasim, Hiltz et al. 1995). A knowledge building strategy sees the learner as an active participant, interacting with the environment. In this view, learning is "the active struggling by the learner with issues" (Duffy and Cunningham 1996, p.174). This way the learner actively constructs knowledge by formulating ideas built on reactions and responses from the environment. Therefore, as an alternative and a contrast to objectivism, a constructivist model of learning is put forward in this research. The constructivist model stresses the crucial relationship between new experience and what is already known, since people can only understand what they have constructed themselves (Leidner and Jarvenpaa 1995). Learning develops through encounters with new information that is different enough to be stimulating, but not so alien that it cannot be assimilated into the learner's mental structures that constitute her present state of understanding (Watson 1996). Real learning must

build on the students' own knowledge, needs and interests, and the learners must be motivated to learn (Schank 1997). In practice, some students are motivated and become very involved with a subject merely by their exposure to it. But this is an exception rather than a rule (Bigge and Shermis 1999).

Motivation in an educational context is strongly related to rewards—either *extrinsic* or *intrinsic*. Bruner recommends a considerable de-emphasis of extrinsic rewards and punishments (in (Bigge and Shermis 1999, p.148)). Instead Bruner sees a need to emphasize intrinsic motives and rewards in the forms of (1) the satisfaction that is gained from quickened awareness and understanding, (2) the challenge to exercise one's full mental powers, (3) a developing interest and involvement, (4) the satisfaction gained from one's identification with others, (5) pleasure received from one's cognitive or intellectual mastery, (6) one's sense of competence and accomplishment, and (7) the development of "reciprocity," which involves a deep human need to respond to others and to operate jointly with them to achieve an objective.

The objectivist and the constructivist model can also be related to surface and deep approaches to learning (Ramsden 1992). This is summarized in table 1 below.

The concept of constructivism has come to cover a wide diversity of perspectives. They seem to have the following in common (Duffy and Cunningham 1996, p.171):

> ***"(1) learning is an active process of constructing rather than acquiring knowledge, and (2) instruction is a process of supporting that construction rather than communicating knowledge".***

Writings on constructivistic learning have altered in their perspective over the last twenty years to include more than the mental activity of individuals in learning (Watson 1996). Social interaction among the learners is added to the constructivist model and it becomes collaborative (Slavin 1990). Collaborative learning refers to an activity where two or more people work together to create meaning, explore a topic, or improve skills (Harasim, Hiltz et al. 1995). The individual and the social view of constructivism are also characterized as a cognitive constructivist view and sociocultural constructivist view (Duffy and Cunningham 1996, p.175).

Objectivism - Surface learning	Constructivism - Deep learning
- Focus on the signs (e.g., words and sentences of the text, or un-reflected on the formula needed to solve the problem). - Atomistic view of knowledge. - Focus on unrelated parts of the task. - Memorize information for assessments. - Associate facts and concepts unreflectively. - Fail to distinguish principles from examples. - Treat the task as an external imposition. - External emphasis: demands of assessments, knowledge cut off from everyday reality.	- Focus on what is signified (e.g., arguments and concepts applicable to understand and solve the problem). - Holistic view of knowledge. - Relate previous knowledge to new knowledge. - Relate knowledge from different courses. - Relate theoretical ideas to everyday experience. - Relate and distinguish evidence and argument. - Organize and structure content into a coherent whole. - Internal emphasis and intrinsic motivation: a window through which aspects of reality become visible, and more intelligible.

Table 1: Objectivism and constructivism (Adapted from Ramsden 1992, p.46).

2.2. Collaborative learning

Being a "sage on the stage" is not an obvious choice for many teachers today. Rather, they choose to be a "guide on the side" by applying understandings such as collaborative learning or *horizontal interaction among learners* when designing learning activities.

Collaborative learning is a broad area of both research and practice. Collaborative learning consists of activities using peer interaction, peer evaluation, and peer cooperation, with some structuring and monitoring by the teacher. The basic premise underlying this is that learning emerges through shared understanding of multiple learners (Leidner and Jarvenpaa 1993). The essence of collaborative learning is that active participation is critical to the learning process and that learners have knowledge valuable to other learners. Learning is sharing, and the more that is shared the more is learned. It is assumed that students are likely to learn as much from each others as from course material or from the teacher or the tutor. It is even claimed that the most powerful and sustainable learning process occurs among peers who pull each other rather than being pushed by experts. This way, collaborative learning is a creative process of articulating ideas, "having them criticized or expanded, and getting the chance to reshape them or abandon them, all in the light of

peer-discussion" (Rowntree 1995, p.207). Whereas some collaborative learning occurs spontaneously, most collaborative learning activities must be initiated more explicitly.

Shneiderman proposes a three component philosophy called Relate-Create-Donate which emphasizes: Relate: work in collaborative teams, Create: develop ambitious projects, and Donate: produce results that are meaningful to someone outside the classroom (Shneiderman 1998). However, it should be clear that "collaboration" is not simply a treatment, which has positive effects on all participants. Collaboration is a social structure in which two or more people interact with each other, and according to Dillenbourg (Dillenbourg, Baker et al. 1996) under some circumstances, some types of interaction have a positive effect. Not all learners are ready for a constructivistic and collaborative kind of learning. Many learners still feel inclined to say: "OK, so we've discussed; now tell us what to learn for the exam" (Rowntree 1995, p.214).

The sociocultural contructivist's view emphasize the distribution of cognition in the environment (Duffy and Cunningham 1996, p.179). Collaborative learning can be understood in terms of distributed cognition, which is about sharing information and building knowledge. It implies collaboration as people are interacting and learning together using technology (Roschelle and Teasley 1995), but also collectiveness, when people are successful in building a shared representation and to some extent shared cognitive system (Dillenbourg, Baker et al. 1996). Distributed cognition extends beyond an individual's mental activity to include everything in that individual's environment; it comprises the individual, peers and tools. Hence, it is the interaction among these that ensure individual as well as collective knowledge building. This should be compared to the more traditional understanding of "cognition" as something residing in an individual.

When students and educators are engaged in collaboration, the teaching and learning process becomes different than in traditional teaching. The students, rather than being passive recipients of information, have to be active and engaged cognitively, and articulate, explain and criticize. The educator has to release the process of learning and knowledge building to the students and in the students. However, the responsibility of creating a good atmosphere and making learning possible still resides very much with the educator. See for instance (Laurillard 1993) and (Ramsden 1992) for a discussion of the new role of the teacher.

2.3. Problem Based Learning

Much of the inefficiency in education that research has exposed stems from the way many school subjects are organized and presented (Bigge and Shermis 1999, p.264). In an exploratory view of learning, the subject matter is not pre-organized and presented to the learner, but to be learned on its own terms. The emphasis is on the problems or phenomena the learners identify and not those that are labeled by educators or in textbooks. Since the focus is on problems identified, sensed or felt by the learners, there are openings for discussions among the learners. Problems that are real, that might arise in the learner's life, or that are known to the learner, have enormous potential for learning (Guzdial, Kolodner et al. 1996). Engeström argues that the problems must be created by the learner, not presented to them, and learning is the mastery from actions transferred to a new activity (Engeström 1987, p.2).

Problem based learning is one possible way to organize education to promote exploratory learning. Problem based learning is *not* just another way of teaching since it builds on a fundamentally different understanding of learning than traditional teaching (Silén, Normann et al. 1993; Hård af Segerstad, Helgesson et al. 1997). Problem based learning represents a significant challenge to orthodox beliefs about education and learning (Margretson 1991). Boud and Feletti describe problem based learning as (Boud and Feletti 1991, p.14):

> ***"… a way of constructing and teaching courses using problems as the stimulus and focus for student activity. It is not simply the addition of problem-solving activities to otherwise discipline centered curricula, but a way of conceiving of the curriculum which is centered around key problems in professional practice".***

They continue:

> ***"… problem based courses start with problems rather than with the exposition of disciplinary knowledge. They [the problems] move students towards the acquisition of knowledge and skills through a staged sequence of problems presented in context, together with associated learning materials and support from teachers" (ibid. p.14).***

Charlin (Charlin, Mann et al. 1998) highlights three core principles of problem based learning: (1) the problem acts as a stimulus for learning; (2) it is an educational approach, not an isolated instructional technique; and (3) it is a student-centered approach. In problem based learning the students' own questions, experience, formulations and conceptions of

problems serve as the basis for learning. PBL is commonly claimed to be a method that will assist students in developing a set of competencies. For instance, adapting to and participating in change; dealing with problems, making reasoned decisions in unfamiliar situations; reasoning critically and creatively; adopting a more universal or holistic approach; practicing empathy; appreciating another person's point of view.

The problem based learning process can be more or less structured or open for the students (Harden and Davis 1998). We can distinguish two end points of a continuum (Ellis et al 1998, p.46b). First, in a guided problem based learning approach, the students face a problem (usually one that is defined by the teacher) to solve as a group. While this drives the students' needs for knowledge construction, both the nature of the student (e.g., less experienced in self-directed learning) and the nature of the subject require guidance and some sequencing of the learning events (i.e., the acquisition of knowledge). In this case, traditional lectures would be used to present (in the problem context) fundamental concepts at appropriately-timed points in the problem development, and a range of resources would provide assistance in the detailed knowledge acquisition during the learning process.

In full problem based learning, on the other hand, the nature of the problem guides and drives the whole learning experience. There are no formal expositions of knowledge from the *expert*, and the students develop resources based on requirements they determine. While some resources for both the support of the process and the subject content may be pre-defined and developed, the students also develop appropriate resources to assist in their learning. In fact, the students themselves become a resource in the collaborative process.

In many ways, problem based learning is an implementation of the constructivistic and collaborative models of learning. It is a change in understanding of learning from transfer of information from teachers to students towards individual construction of knowledge and social interaction since the group is an important resource in problem based learning. To engage learners, PBL aims to challenge them enough to become involved in the problem and eventually, in the ideal situation, be true "problem owners." The ownership of the problem is one of the central principles of problem based learning as it is asserted that ownership is crucial for deep learning. To assist students in becoming problem owners they are challenged with an authentic task or problem that is relevant and

presented in a context. This way the students experience the kind of situations they will be dealing with in professional life. The importance of making the experience as concrete as possible is emphasized by for instance Kolb (Kolb 1976).

Since problem based learning encourages open-minded, reflective, critical and active students it is a threat to teachers who strive to maintain total control over the content to be learned and demand absorbing, passive students. Educators who conceive education as a one-way process of information transmission and restrict the notion of problem to small, atomic, single difficulties with a single optimal solution are uncomfortable with PBL.

While there is no fixed set of practices for the range of learning activities that fit the problem based learning approach, there are certain characteristics that can be used to identify practices as more or less suitable. These characteristics are the following: (1) as far as possible *real-life* problems should be used to engage the learners in the learning process, (2) subject content should often cross the traditional subject boundaries, (3) learners should collaborate in small groups to develop solution(s) to the problem, and (4) the groups should be assisted by a facilitator who is not necessarily an acknowledged expert in the content area that relates to the problem.

A common misinterpretation is that problem based learning is giving all the responsibility to the students. On the contrary, the responsibility lies with the teacher, the ability of which to establish a good environment for the learning process is crucial. Often problem based learning attempts have failed because what the educator has chosen as *problem* has actually not been a problem in a psychological sense, since a learning problem in a PBL context must create psychological tension in the learner (Bigge and Shermis 1999, p.280). Teachers new to problem based learning may be tempted to give students key variables, too much information, or problem simplification during the process. Ownership of the problem is essential. If the students do not own the problem, they will spend their time figuring out what the teacher wants and wait for extrinsic cues from the teacher.

2.4. Experiential Learning

Experiential learning refers to small group work, were what is learned is directly related to what happens in the group and how it happens.

Experiential learning is participative, interactive, and applied. It means contact with the environment and confrontation with processes that are uncertain. Experiential learning involves the whole person; learning takes place in both cognitive, affective and behavioral dimensions (Gentry 1990). The educator is responsible for providing the experiential stimuli. The type and quality of the stimuli will vary depending on the pedagogical approach applied. Some stimuli might be quite delicate, other stimuli open with a *bang* (Schank 1997).

Various terms have been used to label the process of learning from experience. Learning by doing was introduced by Dewey and used by for instance Graf and Kellogg (Graf and Kellogg 1990). Others have discussed this in terms of experience based learning, trial and error and applied experiential learning (Gentry 1990), and as reflection in action (Senge 1995). The Association for Business Simulation and Experiential Learning (ABSEL) Task Force defines experiential learning as:

> ***"A business curriculum-related endeavor which is interactive (other than between teacher and pupil) and is characterized by variability and uncertainty" (Gentry 1990, p.10).***

In experiential learning, concrete experiences are subjected to individual and group reflections, referred to as process evaluation, as well as attempts to generalize in order to be able to experiment with new behavior. But, experience alone does not automatically lead to learning. Argyris call this double-loop-learning (Argyris 1977). An experience must be accompanied by reflection on the experience. Reflection is described as the conceptual tool for understanding the ambiguous and inexhaustible (Rognhaug 1996). Rosenørn and Busk Kofoed (Rosenørn and Busk Kofoed 1998) distinguishes among three forms of reflection, or reflection periods. First reflection-in-action, which is similar to Senge's notion (Senge 1995), second, reflection-on-action, which takes place after the learning activity, and third, reflection-for-action, where participants in an learning activity reflect on which types of problems they hope to solve more successfully in the future than in the past.

The emotional involvement is vital to learning, imprinting the experience in the mind (Schank 1997). The learning can be conceptualized on two levels. On the one hand, there is individually oriented learning: (1) self-awareness, reflections on one's own values, preferences and behavior in various work groups and feedback from others, (2) recognition that people are different, and that such differences can be productive, and (3)

empathy by getting insight into other individuals' values, ideals, orientations, etc. On the other hand, there is group and organization oriented learning involving the observation of group dynamics, processes and behavior, such as group roles, development stages, cohesiveness, climate, conflict resolution, exercise of power, projections and other aspects of the emotional and cognitive tensions which all are characteristics of the group.

Experiential learning has been practiced since the early 50s. Examples of experiential learning are internships, live case, case studies, role-play, games and simulations. Simulations of different types are common and have long been used to present and visualize complex matters such as mathematical, production and logistic processes. A number of general characteristics of experiential learning activities must be under the control of the educator or designer of the activity to assure the outcome of the activity (Graf and Kellogg 1990). First, *chained decisions*, where the result of one set of decisions influences the rest of the decision making process. Second, *debriefing*, which refers to the type of debriefing that is given after the activity has been finished. Third, *skill focus*, that refers to the type and range of skills being taught. And more recently the fourth, *computerized*, which refers to the rationale in the use of computers delivering the activity.

2.5. Assessment of Learning and Examination

Whereas assessment of learning and examination of different types are used throughout the education system, there are many competing, and sometimes conflicting, understandings of the meaning and purpose of assessment and examination (e.g., Kvale 1975; Rowntree 1977; Ramsden 1992).

Examination as control is the dominating conception of examination. It is necessary to control if the students have learned, or rather remembered, what they are expected to. The instrument of choice is a written exam or a term paper. Preferably at the end of the course so the whole course can be examined. Understanding and analytical abilities are not really asked for in traditional examination. If so, the instructor would have problems in assessing the student. Both students and educators are more comfortable if answers can be considered as objectively right or wrong.

From the control perspective, the outcome or the product of educational activities is assessed and graded. This is also referred to as

summative assessment. Unfortunately the requirement of a written exam is the main interest for many students. A control perspective restricts students from engaging in deeper learning and understanding, and instead pushes them toward memorizing ideas and facts. Educators may encourage critical thinking when they are teaching, but examine their students according to conformity in ideas and detailed knowledge about facts.

Dissatisfaction with current assessment approaches has led to an exploration of feasible alternatives. Assessment is relativistic as it is about several things at once according to Ramsden (Ramsden 1992). Assessment is …

> ***"… about reporting on students' achievements and about teaching them better through expressing to them more clearly the goals of our curricula. It is about measuring student learning and it is about diagnosing specific misunderstandings in order to help students learn more effectively. It concerns the quality of teaching as well as the quality of learning: it involves us in learning from our students' experiences, and it is about changing ourselves as well as our students. It is not only about what a student can do; it is also about what it means he or she can do" (ibid. p.182).***

If we understand assessment as helping students to learn and educators to learn about how best to teach them, in other words formative assessment, we also know that learners often require extra support to engage in unfamiliar tasks. Students are a diverse population, they vary in knowledge, skills, interests, and learning styles. To meet this diversity, one understanding of formative assessment is scaffolding. Scaffolding is an educational term that refers to the support provided so that learners can engage in activities that would otherwise be beyond their abilities (Jackson, Stratford et al. 1996; Jackson, Krajcik et al. 1998).

Formative assessment and summative assessment have also been discussed in other terms as there continues to be a raging debate over the relationship between assistance and assessment. In this debate, it is generally agreed that assistance promotes learning, growth and development. Rather than measuring the minimum competencies, assistance starts with where the learner is, and then designs plans for promoting acquisition and development of new skills. In contrast, assessment implies quality control, providing educators with means for deciding whether the learner has acquired the minimum level of knowledge. However, grading and categorizing should not, as many people seem to think, be viewed as a "bad thing" (Ramsden 1992, p.182). Exams

are stimulating to many students, and they are also efforts that are tangible. It is very clear that educators face a dilemma, since they are many times responsible for both helping students to learn, but also responsible for grading the students. In other words, assessment of learning and examination are problematic tasks.

In this section I have discussed my grounding assumptions about the teaching-learning process, they are constructivism, collaborative learning, problem based learning, experiential learning and formative assessment of learning.

3. Technological Background

This section discusses the development and use of educational technology in general and more specifically the use of information technology to facilitate learning. In making learning possible, information technology is a powerful tool (Pea 1993), and can *"facilitate the development of knowledge building communities"* (Scardamalia and Bereiter 1994; Scardamalia and Bereiter 1996, p.6). The importance of understanding the underlying pedagogical assumptions when designing IT for educational purposes is emphasized by for instance (Laurillard 1993; Leidner and Jarvenpaa 1993; Leidner and Jarvenpaa 1995).

There are many opportunities with information technology for improvement and development of educational practice. However, with opportunity comes the danger of applying poor solutions to non-existing problems or in some cases even perpetuate non-desired behavior among students and teachers. The use of information technology in an educational setting will reflect, either intentionally or inadvertently, the existing theory of learning as discussed above. Guided by their theory of learning, educators have been using a diversity of technologies to make teaching better, more effective, as an instrument for rationalization (Ågren 1997, p.15) or for some other reason. Over the decades, a variety of increasingly sophisticated applications of instructional technology have been developed and put to use in education.

The earliest attempts to use instructional technology date back to the first quarter of this century when the first teaching machine was introduced. Later, in the 50s and 60s, commercial learning kits permitting self-instruction of basic skills in reading, writing and mathematics were available. Programmed instruction became the format of choice for many

teachers in the 70s and 80s. With the arrivals of microcomputers in schools, enthusiasts adapted a vision of computers as tools for presenting programmed instruction, small steps at a time, and multiple choice questions with immediate feedback—right or wrong. All in line with behavioristic conceptions of the good learning process. In fact, most computer use in education has, until recently, taken a behavioristic position. Computers have largely been used as workbooks, drilling students in the learning of concepts, facts, spelling, grammatical usage and formulae. Individualized education became possible with self-instructing and self-assessing computer programs (Rognhaug 1996). This detailed and systematic potential has seemed irresistibly attractive to over 30 years of computer experts who have dominated the area of computer based instruction (CBI) or computer based training (CBT). And today, it is claimed, it is easier than ever, due to user friendly software, to produce *bad* learning materials (Ross and Moeller 1996).

Let me give a short example of my own experience of this technology. Being a citizen of Atlanta for six months, I was required to have a Georgia driver's license. To get the license I had to visit the proper authority and answer questions concerning driving. The standardized procedure was implemented in a mechanical device where a question appeared on the screen and I had to press the right button. The machine then signaled "right" or "wrong." A woman from an ethnic minority was standing at the machine next to me (the room had about 25 of them); she was pressing the buttons at high speed, obviously not thinking about the questions. But the machine "beeped" right every time. I later found out that this ethnic community in the city is quite large and that this machine were asking the questions in their language (all the other machines asked the questions in English, and of course each of them were asking different questions). Many of the drivers to be had (probably) just memorized the sequence of the answers, and by that had become authorized and safe drivers. (Yes, I did pass too).

The use of computers in education has caused a great deal of confusion and debate. Much of the use has suffered from a lack of a sound educational perspective. Hawkins (Hawkins 1993) is among those who stress that computer technology has been brought into the education system in the wrong manner. It has been integrated with traditional teaching, which, as discussed above, emphasizes active transmission and passive absorption of factual information. Traditional teaching may not be

viable for the contemporary technological environment and new teaching approaches will be needed to fully exploit recent technological advances (Leidner and Jarvenpaa 1993). There are approaches moving away from computer based instruction and towards constructive models of learning. Hypertext is one example of this, where dynamic linking of concepts or chunks of information in one document relates to concepts or chunks in other documents. The learner controls the movement throughout the written material and constructs the sequence (Kendall, Kendall et al. 1996).

Computer supported collaborative learning (CSCL) is a notion developed from the field of computer supported collaborative work (CSCW). CSCW is often conceptualized in the dimensions of time and place (Johanssen 1988), which also can be applied for distinguishing different forms of computer supported collaborative. Distance education refers to the educational activities where learners are physically apart from the teacher or the teaching institution for the major part of the learning process (Rumble 1989), and the teaching acts are separated in time and place from the learning acts (Naidu 1994). The intersection of computer supported collaborative learning and distance education is one understanding of collaborative learning where the collaborating individuals are separated by geographical distance (Fjuk 1998). This domain of educational interaction shares attributes of both traditional education and distance learning (Harasim 1989).

There is a shared understanding that communication technologies such as electronic mail, bulletin board services, computer conference systems, World Wide Web, etc., have a profound effect on education as they create environments suitable for learning. Asynchronous learning network (ALN) is commonly used as a notion to integrate these technologies with an explicit pedagogical idea (Hiltz 1994; Bourne, McMaster et al. 1997). The asynchronous learning network environment is a portfolio of network based support tools where electronic mail provides a uniform mechanism for person-to-person communication. ALNs are built using different tools for computer mediated communication (CMC). Examples are electronic mail, bulletin boards and newsgroups, synchronous chat systems, computer conference systems, group decision support systems, and most recently, the World Wide Web (WWW) (Hiltz and Wellman 1997). In this way, an asynchronous learning network can

be understood as an IT infrastructure supporting educational activity. The asynchronous learning network can be characterized as supporting "anytime, anyplace" learning.

In an ALN, learners form a community engaged in collaborative learning at the time and place of the individual learner's convenience (Bourne, McMaster et al. 1997). By slowing down interaction, learners are given time for reflection, and ideas, questions, comments, etc., can grow and mature before being shared with other learners. On line course material is provided as well as areas for submission of individual and group assignments. Autobiographical information about the members of the learning community and a collective diary is also common in ALNs. The key activity in an ALN is the discussion, which often is asynchronous. Learning processes and the role of educators and learners in ALNs are radically different from traditional classrooms (Harasim, Hiltz et al. 1995). An important issue to remember is that ALN based learning is a social process, since *"though the classroom is virtual, the relationships and the learning it supports are real"* (Hiltz and Wellman 1997, p.47). We must also remember that interacting in asynchronous learning networks is still a new and initially alien social world to many participants (Rowntree 1995).

4. Research Aim

The aim of this research is to improve educational practice with information technology. The context for the research is higher education. But the research is also relevant for other areas of organized education, e.g., elementary school, high school and corporate training. The overall question is not whether we should use information technology in education, but how we should use it in well-grounded pedagogical ways to improve the quality of educational activities.

My research is motivated by a strong belief that information technology adds dimensions to teaching and learning, in particular the educational ideas discussed in section 2. The research is also motivated by the seemingly difficult situation many teachers are facing currently. The teachers I am thinking of are those who are not only faced with the current trend of migrating education from teaching to learning, which is a fundamental change of the role of the teacher, but are also expected to use information technology to enhance their teaching, and feel uncomfortable with the whole situation. Hence, a complex and difficult situation has

arisen in education with a variety of issues and problems to understand and ultimately to be solved.

With the aim of improving educational practice with information technology, one possible research approach is "the New Informatics." The New Informatics, as defined by Dahlbom is " ... a theory and design-oriented study of information technology use, an artificial science with the intertwined complex of people and information technology as its subject matter" (Dahlbom 1996, p.29). He continues, "With information technology we are rapidly transforming our society, our organizations, and our lives. All these changes go together" (ibid. p.43). One important change is a change of view of education, from a factory with a well-regulated production line to a market-place bustling with interaction and negotiation among all actors.

Therefore, the mission undertaken in this research is improving educational practice with information technology. This is done by: First, exploring the current educational situation with the purpose of investigating how information technology can be used in the light of the educational ideas discussed in section 2. Second, we have designed prototype applications and methodologies for using the applications. Third, we have used the applications and the methodologies in educational settings. And, fourth, the applications have been evaluated in the educational context. The research conducted in this thesis is described in more detail in section 6.1.

5. A Framework: e-ducation

I have developed a framework called e-ducation to summarize my general view of education supported by information technology. e-ducation is derived from the literature and from my experience of research in education and teaching. e-ducation is a framework consisting of three interrelated aspects of education (figure 1 below): These three are:

- **engaged, which refers to an understanding of the process of learning, i.e., that engagement is crucial for learning,**
- **empowered, which refers to the distribution of responsibility among all participants, students and teachers, in educational activity, and,**
- **electronic, which refers to the use of information technology in educational activities.**

The relevance and interrelationship among the three aspects of education are derived from contemporary educational research.

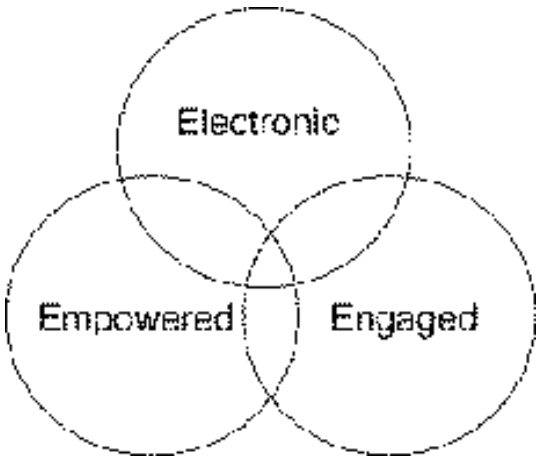

Figure 1: The e-ducation framework

A model or a framework such as the e-ducation framework is of course a simplification since it reduces much of the complexity it aims to model. The e-ducation framework should be approached with the following assumptions and restrictions in mind. e-ducation is of course a play with words. The value of the framework is therefore more pedagogical than analytical. e-ducation concerns educational practice and is a descriptive as well as normative framework. Each of the three aspects are discussed more in detail below, and I end this section with a short discussion of the unity of the three aspects.

5.1. Engaged

Ever since education became formalized in schools, educators have been aware that learning in schools is often inefficient. No matter how much is tried to be taught, it is the learner who decides what is actually learned. Therefore, in e-ducation, engaged refers to the core of learning. The standpoint advocated in this thesis is that for learning to actually take place, the learner has to be not only active in the learning process, but also engaged. Norman and Spohrer (1996) argues that engagement is the factor that can make more of a difference between success of failure than other factors. Development and internalization of knowledge, whatever its form, is an active and truly engaged process. Individuals actively construct their knowledge by relating incoming information to a previously acquired frame of reference.

Whereas engagement is necessary, there is a kind of ”golden mean” in learner engagement, somewhere between apathy and wild excitement, for which the educator should strive. Bruner suggests that “frenzied activity fostered by the competitive project may leave no pause for reflection, for evaluation, for generalization, while excessive orderliness, with each student waiting passively for his turn, produces boredom and ultimately apathy” (Bruner 1960, p.72).

5.2. Empowered

The teachers who are choosing to be a “guide on the side” are empowering the students by establishing an educational climate that contributes to a feeling of student empowerment, and a state in which students feel responsible for and are in control of their learning (Bagley and Hunter 1992, p.23). Empowered is about those educational activities where the learners share at least some of the responsibility for what to learn and how to learn. Confrontation with material and practice in being explorers, problem-finders and problem-solvers permit learners to become partners in determining when they are right and when they are wrong as well as when, and to what extent, material and information are relevant or irrelevant respectively. Do not confuse empowered, how it is used here, with the teacher who has the attitude: “It is up to you, I am not responsible for your learning, you are.” Instead, in empowered education teachers and students share the process of learning. A learner's development of an approach to learning that enables her not only to learn the material that is presented in a formal educational setting but also to learn in such way that she can use the information when solving problems in the future.

Problem based learning is an educational approach where students can be empowered. Problem based learning is *not* another way of teaching, but an approach to learning fundamentally different from traditional teaching. In problem based learning the students' own questions, experience, formulations and conceptions of problems serve as the basis for learning.

But empowerment can also take other turns that are quite different than discussed above. Last year I was participating in a working group on the theme of problem based learning in programming education. After a couple of days working in this group one of my American colleagues highlighted one issue that fortunately is not part of my everyday contact

with students. She told me that students literally were waving the receipt from paying the tuition and saying "Now I've paid, and I expect you to teach me."

5.3. Electronic

One resource that is not lacking at educational institutions today are students' and teachers' access to computers and networks. Computers are now so commonplace in educational institutions that their absence is more noteworthy than their presence (Bigum 1998, p.587). The number of students with access to computers, either their own, the family computer, computers at public institutions such as libraries or university labs, has increased substantially during the last few years. The use of computers in education has been attended by a great deal of confusion and debate. The use has suffered from a lack of a sound educational perspective. Hawkins (Hawkins 1993) are among those who stress that computer technology has been brought into the education system in the wrong manner. To a large extent, information technology has been integrated with traditional teaching, with an emphasis on active transmission and passive absorption of factual information.

However, there is a shared understanding that information technologies such as electronic mail, bulletin board services, computer conference systems, world wide web, etc., have a profound effect on education as they create environments suitable for learning. For instance, computers can *"facilitate the development of knowledge building communities"* (Scardamalia and Bereiter 1994). Information technology offers many possibilities for substantial change to education, but we have to use it wisely.

5.4. e-ducation

The framework unites the three aspects discussed above. It is suggested, that when these three are in balance the value and the effect of information technology in education is likely to be positive. The design and use of information technology in educational activities must be pedagogically well-grounded. Information technology as such will not solve the problems of education. From an informatics perspective, it is possible to take information technology as a point of departure. However, the design of educational information technology should always be

validated by appropriate pedagogical models. In the next section I describe how the e-ducation framework has been applied in this thesis.

6. The e-ducation Framework Applied in Research

In this section, I summarize the research documented in the six papers. First I discuss the overall approach or philosophy that guided the research. I then describe the research conducted in each paper in more detail.

6.1. Research Approach

Informatics research has a pluralistic tradition where several methodological paradigms co-exist (Galliers 1992; Dahlbom 1996). The dominant topic of research has been the development and refinement of systems development methods (Stolterman 1995). More recently, the conception of informatics research as a "*design oriented study of information technology use with the intention to contribute to the development of both the use and the technology itself*" (Dahlbom 1996) is influencing much of the conducted research. From an informatics perspective, new use domains, in all fields, are constantly made possible by advances in information technology and the central interest of informatics is to intervene and contribute to the process of change rather than to just observe and describe the process. Information technology changes people's work (in this case education) and our interest is to augment their skills by the technology rather than replace them with information technology (Ehn 1988).

Educational research is described by Entwistle as a thorough and systematic attempt to bring about a better understanding of the educational process, with the purpose of improving the efficiency. The aim for the researcher is to describe how 'learning' occurs and to suggest how different educational activities can influence the quality of the learning (Entwistle 1986).

In this thesis, the term design is used to describe the activity of analyzing the needs, or the possibilities, for the implementation of form and functionality (e.g., Dahlbom and Mathiassen 1993; Simonsen 1994). Current research approaches applied to contribute to both the development of technology and the design of its use is guided by variations of the scientific methods: ethnography and action research. Ethnography aims at describing the culture of a specific domain by observing and participating in this culture. Often, but not necessarily, ethnographic

studies involve longer periods of study to assure the researcher of a deep understanding of the culture. However, ethnographic research in short time periods is also advocated, i.e., "quick and dirty ethnography" (Ljungberg 1997).

The purpose of action research is to solve a problem here and now (Patton 1990). Action research has two aims: to contribute to solving practical problems, and some specific research goal, such as the development of an approach, a method or a conceptual framework. A key assumption in action research is that science can be used by people themselves, in collaboration with researchers, to solve their problems of practice. The combination, and focus, of the two are delicate, "Those involved [in action research] are either doing research with little action, or action with little research" (Foster 1972, p.529). Hägerfors, on the other hand, suggests that in action research projects, theory and practice, thought and action, science and common sense are brought together (Hägerfors 1994, p.2). The standard for judging action research is the evaluation made by research participants and researchers of the solution generated. Action research has been a major approach in Scandinavia, especially within the field of participatory design of information technology (see for instance the special issue of Communications of the ACM (36:4) 1993). Action research in informatics outside Scandinavia has not been frequent (Avison, Lau et al. 1999).

Doing informatics research in education the approaches above, ethnography and action research, are suggested as fruitful in reaching the aim of designing information technology use in education. The researchers' relation to the educational activity is determining the approach. There are basically two alternatives. Doing research as an observer and not participating as a teacher in the educational activity, an ethnographic research approach is suggested. This allows the researcher to observe and understand. A teacher conducting research in her own course is not able to be the outside observer in the same sense for obvious reasons. In researching your own practice an action research approach is suggested.

Action research and consultancy are in some sense overlapping. Simonsen (Simonsen 1994) points out that the difference between them are that in consultancy, the work is controlled by the organization and the person is paid for a specific job, whereas, in action research, the researcher

is not on the payroll of the organization. However, in an educational context this should not be a problem.

The overall research approach applied in this thesis is action research. It is action research since the purpose is to experiment with education through intervention and to evaluate and reflect on the effects of the intervention. The purpose is also to discuss implications on the theoretical foundations, i.e., the pedagogical ideas. Inspired by the pedagogical ideas discussed in the previous section and the possibilities to enhance them with information technology, this research is focusing on design of prototype applications and the use of them in educational activities. This way the research focuses on action and change of practice, all in line with some of the Scandinavian tradition in action research, e.g., Nygaard (1991). Nygaard describes his experience of the project with the iron and metal workers' union in the 70s and states:

> ***"In most research projects the results of the project may be said to be what is written in the research reports. In this project an other definition will be applied: We will regard as results actions carried out by the trade unions, at the local and national levels, as a part of or triggered off by the project" (ibid. p.56).***

The importance of experimentation and providing examples of information technology use in education is advocated by for instance Leidner and Jarvenpaa. They say, "computer-based teaching methods might be encouraged as a means of enhancing classroom learning, although it may require trial-and-error or experimentation to determine the most effective uses of the technology" (Leidner and Jarvenpaa 1993) p.51. The evaluation of the effects on different aspects of education is therefore less emphasized than it would be in other educational research. The reason for this is that there is a need for concrete examples of how information technology can be used in different educational activities. Of course, there is also a need for extensive evaluation of the effects, but I find it more urgent to experiment with a variety of ideas to open up for a dialogue among teachers concerning the use of information technology.

The viability of action research in an education context is discussed by Gibbs (Gibbs 1995) who suggests that: "using research and research tools to intervene, often successfully, in their own courses [...] is the kind of research which gets results" (p.27). The idea of trying out ideas and solve problems in the teacher's own practice, and systematically evaluate and document the work and communicate it to other teachers through the

standard channels, i.e., academic journals, conferences and seminars should get higher status. One problem is that a relatively low proportion of academics read the research journals on teaching in their discipline (Laurillard 1993, p.191). One other problem is that the most common type of paper in these journals concerns a discussion of curriculum content: what should be taught and why. The optimum curriculum sequence is a popular topic for papers, but very little research reports on how students find different learning activities.

The pedagogical ideas discussed in the previous section have inspired the design of prototype information technology applications. My own experience as a teacher has played a vital role. I have applied two different research designs. In the first two papers I describe experiments conducted with students. The students were surveyed and, based on their responses and observations from the experiment, conclusions are drawn and further research is outlined. In the four other papers, information technology prototype applications were designed and implemented. They were then evaluated in experimental settings and in real classroom situations. The research approach in the six papers is described briefly below.

In the first paper, two case studies of information technology project management were combined into a paper based scenario about a failing information technology project. The two case studies are documented in (Nuldén 1996a; Nuldén 1996b). The paper-based scenario was presented to two groups of students. An instrument with both Likert scale questions and open-ended questions about the project was developed. Statistical analysis was applied to analyze the Likert scale questions. Content analysis and categorization of keywords were applied to analyze the open-ended questions (Weber 1985; Patton 1990).

In the second paper, four educational activities were prepared according to the principles of problem based learning. In the evaluation, the four problem based learning sessions were realized as part of a course. The students' experiences of the sessions were captured with a survey via electronic mail and the keywords of their responses were categorized.

In the third paper the findings and experience from the research documented in the first and the second paper served as a point of departure. An electronic mail survey was conducted to investigate how students with experience of problem based learning believed PBL could be improved. With the experience and results from the survey, a prototype scenario based on problem based learning, experiential learning and

interactive multimedia was designed. The scenario was evaluated by observing two groups working with the scenario.

In the fourth paper, the three areas of collaborative learning, asynchronous learning networks, and large introductory courses inspired the conceptual design of a structuring philosophy for introductory courses using asynchronous learning networks. The philosophy was evaluated by designing a course following the philosophy. The students participating in the course were surveyed twice, and the teachers involved were interviewed following a semi-structured interview guide. Some statistical analysis was conducted.

In the research presented in the fifth paper, a three-phase research approach was applied. First, approximately 400 students completed a survey concerning their conception of examination. The instrument used in the survey contained multiple-choice questions and one open-ended question. Statistical analysis was performed on the multiple-choice questions. The answers to the open-ended question were analyzed through analysis of keywords in the responses. The keywords were then categorized. The result from the survey served as input to the design of two computer based applications. The applications were then evaluated in a course. The students participating in the course were surveyed about the two applications. The data from the survey were then analyzed through statistical analysis.

In the last paper, the notion of formative assessment and information technology in the form of a mobile computing device, also called handheld personal digital assistants (PDA), inspired the design of an application for the purpose of communication from teachers to students. A prototype application was designed and implemented. The prototype was then evaluated in an experimental setting where two educational activities were simulated. The data collection was conducted through a group interview (Patton 1990, p.17).

6.2. The six papers

This thesis contains six papers and this introduction. This section summarizes the six papers and at the end of the section I discuss them in relation to the e-ducation framework presented above.

- **First paper: "What about failures? Suggestion for an Alternative Computing Education Activity." The paper describes an experimental study conducted to determine the students' responses to the phenomena of "project escalation". The research was conducted and authored together with Helana Scheepers. Published in *Failure & Lessons Learned in Information Technology Management*, Vol. 2, p.133-144, 1998.**

In computing education, students are given some real life experience of the development of computer systems. This experience usually does not include project failure and especially not escalation situations with difficult decisions that deepen or compound the problems a project has. It is argued that traditional "teaching-by-telling" will not work in learning about escalation situations. Instead the only way in which students will be able to recognize and learn about escalation is by actually experiencing a project that is escalating and that will fail. To support this argument an experiment where students were to make decisions about a project were conducted. From the results of the experiment, we conclude that students act in the same way as practitioners do when making decisions about projects. The students were convinced that the right decision was to invest more resourses and let the project continue. Hence, we claim that if we do not change the way in which students are taught, we perpetuate the problem of failing projects. Of course, we are not suggesting that all projects facing problems should be stopped (see for instance (Drumond 1998) for a discussion). This first paper ends with ideas about how to change or rather enhance computing education to make students aware of, but also make them understand the problem of escalation situations. The conclusion is that traditional teaching is a poor approach when teaching about complex real world problems such as escalation of commitment. We suggest how educators can engage learners in a failing project experience.

- **Second paper: "Needed: An Alternative Approach to Prepare Information Technology Professionals" The paper describes a project where the relevance and viability of problem based learning in information technology education were evaluated. Accepted for publication in *Educational Practice and Theory*.**

In this paper I report from a project where problem based learning was included in my own teaching. Four traditional lectures in an introductory course in information systems development and databases for first year students were replaced by interdisciplinary problem based learning

sessions. The *problems* were designed to invite the students to approach contemporary issues in systems development projects. The problem based learning sessions were then evaluated by surveying the participating students two months after the sessions took place. The project was motivated by, firstly, current trends in education and learning, and secondly, the role IT professionals play in shaping the future society. I claim that traditional teaching does not coincide with the demands of the information technology professionals. Problem based learning is proposed as an alternative where both knowledge and methods for acquiring the knowledge is considered. I report on lessons learned and conclude that problem based learning is a viable approach to train IT professionals after considering some critical factors concerning introduction and implementation.

- **Third paper: "Interactive Multimedia and Problem Based Learning: Experiencing project failure" In this paper we describe the design, implementation and evaluation of a multimedia based simulation for project management education. The research was conducted and authored together with Helana Scheepers. Accepted for publication in *Journal of Educational Multimedia and Hypermedia*.**

In this paper we discuss ideas on how to integrate interactive multimedia in experiential learning and problem based learning. Experiential learning combined with interactive multimedia has received a great deal of attention in both educational practice and research. The advancement of multimedia technology also provides an opportunity to extend problem based learning and combine it with experiential learning. We find openings for turning stories, anecdotes and real world problems into cases and simulations. To elaborate the ideas further we focused on the first phase of problem based learning, often called the "vignette." The vignette is used by the teacher to present a problematic situation that should serve as stimulus and starting point for a self-directed learning process. To enhance this starting point we looked into the area of experiential learning since the core of experiential learning is—stimulus and starting point. To add to our own ideas, we also surveyed both students and teachers who had experience of problem based learning to find ideas on how the vignette could be enriched or transformed by the use of interactive multimedia. Based on this we designed and implemented an interactive multimedia vignette prototype. The prototype was evaluated in two different settings:

university and industry. The conclusion is that the multimedia prototype works as a tool to integrate experiential learning and problem based learning. The interactive multimedia added important dimensions to the first phase of the problem based learning approach. The results from the evaluation were systematized and compiled into a tentative methodology, called PIE (problem based learning, interactive multimedia, and experiential learning).

- **Fourth paper: "Thematic Modules in an Asynchronous Learning Network: A Scandinavian Perspective on the Design of Introductory Courses." The paper is discussing and evaluating a philosophy for design of large introductory courses. Accepted for publication in *Group Decision and Negotiation*.**

In the fourth paper I discuss an educational philosophy and propose a framework for structuring introductory courses in higher education. The philosophy is rooted in a Scandinavian tradition of social settings and the culture of Swedish education. Two elements are central in the philosophy: First, the notion of a thematic module (TM) which is a unit for studying a limited subject matter or topic. Second, asynchronous learning networks (ALN), which is the use of computer mediated communication for time and place independent interaction among distributed learners, i.e., collaborative learning. To evaluate the philosophy, a course, "Introduction to Informatics," was designed following three central assumptions of the philosophy. First, thematic modules are appropriate for structuring an introductory course, second, asynchronous learning network is a viable environment to enhance thematic modules, and third, thematic modules in asynchronous learning networks is a suitable approach for educators who wish to engage students and fellow educators in constructive and collaborative learning activities. To investigate the assumptions, both qualitative and quantitative data were collected and analyzed. The quantitative data gathered are very limited, but give indication for further research. The paper ends with a framework guiding the design of introductory courses using thematic modules and asynchronous learning networks.

- **Fifth paper: "Computer Support for Formative Assessment." The paper describes the design and evaluation of alternative forms of computer supported examination. Submitted for publication in *Information Technology and Management*.**

This paper describes research investigating examination of business students. The overall goal of the research is the design of computer support for collaborative learning and formative assessment. The question guiding the research presented in this paper was: How can computers support examination of business students? To approach this question, the research was conducted in three phases. The first phase investigated business students' perception of examination. The methodology applied was data collection through a survey. Statistical analysis and interpretative content analysis were performed. The second phase was the design and implementation of two computer web-based applications for examination. The first application is based on the notion of mandatory participation, and the second is based on the concept of peer review. In the third phase, the use of the two applications was evaluated in a course with eighty business students. The main findings are the following: The first phase showed a diverse perception of examination among the students. Mandatory active participation in computer-based discussions combined with peer review of reports is claimed to be a viable approach for examination in a Business School environment.

- **Sixth paper: "The *ExCon* Project: Advocating Continuos Examination." In this paper an application for a mobile computing device (Newton™) was designed to facilitate communication and feedback in student-teacher interaction. Published in *Proceedings of the SIGCSE (Computer Science Education) ACM Conference* 1998. p.126-130.**

In this paper it is claimed that traditional examination often is destructive to the process of learning. It does not matter how good intentions educators have, it is the way they examine students that will have the strongest impact on how the students learn. The goal of the ExCon project is intervention in traditional examination. The paper discusses an alternative model for understanding assessment and examination of students. Product assessment is questioned as an appropriate approach. Instead it is argued that educators should, to a larger extent, provide the student with questions and other types of feedback during the ongoing activity and use communication as an important element of the examination. For this purpose, a software prototype for a mobile computing device to support the educator was designed and developed. An evaluation of the prototype was performed and the paper ends with some thoughts on the viability of the prototype in supporting alternative assessment and examination.

7. Results

In this section I summarize the results from the research described in the six papers and the introduction, and discuss the implications of the findings. The papers provide examples of novel and experimental use of information technology in educational activities. The suggested use of information technology in education in this thesis is not *extreme* and the use builds on established pedagogical ideas. The main results in this research are:

- **The e-ducation framework which can be applied to understand important trends in education. The framework is derived from contemporary educational research. e-ducation summarizes my research since all six papers have e-ducation as the underlying foundation.**

- **The thesis has introduced the PIE approach (problem based learning, interactive multimedia and experiential learning). Information technology, especially the world wide web and the Internet, can improve problem based learning since the possibilities for learners to search, and find, information is unlimited. In PIE however, the focus is on information technology use for the initiation of the learning process. Problem based learning as an educational activity can be improved if the *problem* is introduced by interactive multimedia.**

- **The philosophy of Thematic Modules (TM) was developed to structure collaborative educational activities in asynchronous learning networks (ALN). Thematic modules are not, in contrast to most other ALN based activities, optional. Rather, the active participation of the learner is compulsory since they can participate at the place and the time of their convenience.**

- **Concrete examples of alternative forms of computer supported examination. MPE (mandatory participation as examination), PeeR (peer review of reports) and Tracker (a handheld computer application) are three concrete examples of how information technology can be used to support different assessment approaches.**

What are the implications of the findings? The framework e-ducation can be used to guide research on both education and educational practice. PIE and Thematic Modules are educational approaches ready to be applied. The three forms of computer supported examination are prototypes but the evaluations show that they have a potential in improving assessment of learning.

In the preface I suggested that there is a changing view of teaching and learning in the university context, from a factory metaphor with a well-regulated production line to a market-place bustling with interaction and negotiation among all actors. This is only partly true. The factory metaphor of the university is strong, and I am worried that we are, with the help of information technology, reinforcing the factory.

However, concrete, pedagogically well-grounded examples of information technology use in educational activities will invite more teachers to try alternatives to their current teaching. I think this is a necessary starting point to initiate a dialogue among teachers. Information technology offers a wealth of possibilities, but most teachers need help to get started. Information technology by itself will not add very much to education. Rather, it is "the method of using the technology and not the technology itself that has an effect on classroom activity" (Leidner and Jarvenpaa 1993, p.50). In this thesis, the approach has been action oriented because I believe there is a need for action and concrete novel examples of information technology use in education.

7.1. Further Research

This thesis has presented a number of applications to be used in an educational context. The applications were evaluated but there is a need for further and more systematic evaluation. There is also need for more longitudinal studies with experimental groups and control groups to investigate the effects of information technology in educational activities.

The value of prototypes in providing examples for other teachers is important. Therefore we should continue to be creative in designing prototypes and applying them in educational settings, and communicate our experience and findings to other educators. The impact of information technology on education has just begun.

8. References

Argyris, C. (1977). "Organizational learning and management information systems." Accounting, Organizations and Society 2(2): 113-123.

Avison, D., F. Lau, M. Myers and P. A. Nielsen (1999). "Action Research." Communications of the ACM 42(1).

Bagley, C. and B. Hunter (1992). "Restructuring, Constructivism, and Technology: Forging a new Relationship." Educational Technology(July): 22-27.

Barker, B. O. and M. W. Dickson (1996). A Model for Infusing Advanced Technology into Teacher Education. Seventh International Conference of the Society for Information Technology and Teacher Education, Phoenix, Arizona.

Bigge, M. L. and S. S. Shermis (1999). Learning Theories for Teachers. New York, Longman.

Bigum, C. (1998). "Solutions in search of educational problems: Speaking for computers in schools." Educational Policy 12(5): 587-602.

Boud, D. and G. Feletti, Eds. (1991). The Challenge of Problem Based Learning. London, Kogan Page Limited.

Bourne, J. R., E. McMaster, J. Rieger and J. O. Campbell (1997). "Paradigms for On-Line Learning: A Case Study in the Design and Implementation of an Asynchronous Learning Networks (ALN) Course." Journal of Asynchronous Learning Networks 1(2): 38-56.

Bruner, J. S. (1960). The Process of Education. New York, Vintage Books.

Charlin, B., K. Mann and P. Hansen (1998). "The Many Faces of Problem Based Learning: A Framework for Understanding and Comparison." Medical Teacher 20(4): 323-330.

Dahlbom, B. (1996). "The New Informatics." Scandinavian Journal of Information Systems 8(2): 29-48.

Dahlbom, B. and L. Mathiassen (1993). Computers in Context: The Philosophy and Practice of Systems Design, NCC, Blackwell.

Dillenbourg, P., M. Baker, A. Blaye and C. O'Malley (1996). The evolution of research on collaborative learning. Learning in Humans and Machines. Towards an interdiciplinary learning science. P. Spada and H. Reimann: 189-211.

Drumond, H. (1998). "Is Escalation Always Irrational?" Organization Studies 19(6): 911-926.

Duffy, T. M. and D. J. Cunningham (1996). Constructivism: Implications for the design and delivery of instruction. Handbook of research for educational communications and technology. D. H. Johansson. New York, Macmillan Library Reference.

Ehn, P. (1988). Work-Oriented Design of Computer Artifacts, Arbetslivscentrum.

Ellis, A, L. Carswell, A. Bernat, D. Deveaux, P. Frison, V. Meisalo, J. Maayer, U. Nuldén, J. Rugelj and J. Tarhio. (1998). "Development and Use of Multimedia And Internet Resources for a Problem Based Learning Environment." SIGCSE, Bulletin inroads, Vol 30 (4), pp. 45-60.

Engeström, Y. (1987). Learning by Expanding. An activity-theoretical approach to developmental research. Helsinki, Orienta-Konsultit OY.

Entwistle, N. (1986). Olika perspektiv på inlärning. Hur vi lär. F. Marton, D. Hounsell and N. Entwistle, Rabén & Sjögren: 11-34.

Fjuk, A. (1998). Computer Support for Distributed Collaborative Learning. Exploring a Complex Problem Area. Department of Informatics. Oslo, University of Oslo: 244.

Foster, M. (1972). "An Introduction to the Theory and Practice of Action Research in Work Organizations." Human Relations 25(6): 529-556.

Galliers, R. D. (1992). Choosing Information Systems Research Approach. Information Systems Research - Issues, Methods, and Practical Guidelines. R. Galliers.

Gentry, J. W. (1990). What is Experiential Learning? Guide to Business Gaming and Experiential Learning. J. W. Gentry, Association for Business Simulation and Experiential Learning (ABSEL).

Gibbs, G. (1995). Research into Student Learning. Research, Teaching and Learning in Higher Education. B. Smith and S. Brown. London, Kogan Page Limited: 17-29.

Graf, L. A. and C. E. Kellogg (1990). Evolution of Experiential Learning Approaches and Future Developments. Guide to Business Gaming and Experiental Learning. J. W. Gentry, Association for Business Simulation and Experiential Learning (ABSEL): 231-250.

Guzdial, M., J. Kolodner, C. Hmelo, H. Narayanan, D. Carlson, N. Rappin, J. Turns and W. Newstetter (1996). "Computer Support for Learning through Complex Problem Solving." Communications of the ACM 39(4): 43-45.

Hägerfors, A. (1994). Co-Learning in Participative Systems Design. Department of Informatics. Lund, Lund.

Harasim, L. (1989). On-line Education: A New Domain. Mindweave, communication, computers and education. R. Mason and A. Keye. Oxford, Pergamon: 50-62.

Harasim, L., R. Hiltz, L. Teles and M. Turoff (1995). Learning Networks - A Field Guide to Teaching and Learning Online. Cambridge, The MIT Press.

Hård af Segerstad, H., M. Helgesson, M. Ringborg and L. Svedin (1997). Problembaserat lärande. Stockholm, Liber.

Harden, R. M. and M. H. Davis (1998). "The continuum of problem based learning." Medical teacher 20(4): 317-322.

Hawkins, J. (1993). "Technology and the Organization of Schooling." Communications of the ACM 36(5): 30-35.

Hiltz, S. R. (1994). The Virtual Classroom: Learning Without Limits Via Computer Networks. Norwood, NJ, Ablex Publishing Co.

Hiltz, S. R. and B. Wellman (1997). "Asynchronous Learning Networks as a Virtual Classroom." Communications of the ACM 40(9): 44-49.

Jackson, S. L., J. Krajcik and E. Soloway (1998). The Design of Guided Learner-Adaptable Scaffolding in Interactive Learning Environments. CHI 98, Los Angeles, ACM Press.

Jackson, S. L., S. J. Stratford, J. Krajcik and E. Soloway (1996). "A Learner-Centered Tool for Students Building Models." Communications of the ACM 39(4): 48-49.

Johanssen, R. (1988). Groupware: Computer support for business teams. New York, The Free Press.

Kaplan, E. J. and D. A. Kies (1995). "Teaching styles and learning styles: Which came first?" Journal of Instructional Psychology 22(1): 29-33.

Kendall, J. E., K. E. Kendall, R. L. Baskerville and R. J. Barnes (1996). "An Empirical Comparison of a Hypertext-Based System Analysis Case With Conventional Cases and Role Playing." DATA BASE 27(1): 58-77.

Kolb, D. (1976). "Management and the Learning Process." California Management Review 13(3): 21-31.

Kolb, D. (1985). Learning-Style Inventory. Boston, McBer & Company.

Kroksmark, T. (1995). "Teaching and Teachers' "Didaktik" - Outlines for a phenomenographic description of teachers' teaching competence." Studies in Philosophy and Education 14: 365-382.

Kvale, S. (1975). "Examinations: From Ritual Through Bureaucracy to Technology." Social Praxis 3(3-4): 187-206.

Laurillard, D. (1993). Rethinking University Teaching - A framework for the effective use of educational technology, Routledge.

Leidner, D. E. and S. L. Jarvenpaa (1993). "The Information Age Confronts Eduation: Case Studies on Electronic Classrooms." Information Systems Research 4(1): 24-54.

Leidner, D. E. and S. L. Jarvenpaa (1995). "The Use of Information Technology to Enhance Management School Education: A theoretical View." MIS Quartely 19(3): 265-291.

Ljungberg, F. (1997). Networking. Department of Informatics. Göteborg, Göteborg University: 222p.

Margretson, D. (1991). Why is Problem-based Learning a Challenge? The Challenge of Problem Based Learning. D. Boud and G. Feletti. London, Kogan Page Limited: 42-50.

Naidu, S. (1994). "Applying learning and instructional strategies in open and distance learning." Distance Education 15(1): 23-41.

Norman, D. A. and J. C. Spohrer (1996). "Learner-centered education." Communications of the ACM 39 (4): 24-27.

Nuldén, U. (1996a). Escalation in IT Projects: Can We Afford to Quit or do We Have to Continue. Information Systems Conference of New Zealand, Palmerston North, New Zealand, IEEE Computer Society Press. 136-142.

Nuldén, U. (1996b). Failing Projects: Harder to Abandon Than to Continue. Projectics, Bayonne, France, Communications Proceedings. 63-74.

Nygaard, K. (1991). How Many Choices Do We Make? How Many Are Difficult? Software Development and Reality Construction. C. Floyd, H. Züllighoven, R. Budde and R. Keil-Slawik. Berlin, Springer-Verlag: 52-59.

O'Neil, M. (1995). Towards a Model of the Learner in Higher Education: Some Implications for Teachers. Research, Teaching and Learning in Higher Education. B. Smith and S. Brown. London, Kogan Page Limited: 117-124.

Patton, M. Q. (1990). Qualitative evaluation and research methods, SAGE Publications, Inc.

Pea, R. D. (1993). "The Collaborative Visualization Project." Communications of the ACM 36(5): 60-63.

Ramsden, P. (1992). Learning to Teach in Higher Education. London, Routledge.

Rigney, J. W. (1978). Learning Strategies: A theoretical perspective. Learning Strategies. H. F. O'Neil. New York, Academic Press: 165-205.

Rognhaug, B. (1996). Kunskap och lärande i IT-samhället. Hässelby, Runa förlag AB.

Roschelle, J. and S. D. Teasley (1995). The construction of shared knowledge in collaborative problem solving. Computer supported collaborative learning. C. O'Malley. Berlin, Springer-Verlag: 69-97.

Rosenørn, T. and L. Busk Kofoed (1998). "Reflection in Learning Processes Through Simulation/Gaming." Simulation & Gaming 29(4): 432-440.

Ross, S. M. and E. W. Moeller (1996). "Multimedia and Hypermedia CBI - A Multidisciplinary Review of Research on Early Design Stages." Journal of Business & Technical Communication 10(4): 428-460.

Rowntree, D. (1977). Assessing students. London, Harper & Row.

Rowntree, D. (1995). "Teaching and learning online: a correspondence education for the 21st century?" British Journal of Educational Technology 26(3): 205-215.

Rumble, G. (1989). "On defining distance education." The American Journal of Distance Education 3(2): 8-21.

Scardamalia, M. and C. Bereiter (1993). "Technologies for Knowledge-building Discourse." Communications of the ACM 36(5): 37-41.

Scardamalia, M. and C. Bereiter (1994). "Computer support for knowledge-building communities." Journal of the Learning Sciences 3(3).

Scardamalia, M. and C. Bereiter (1996). "Engaging students in a Knowledge Society." Educational Leadership 54(3): 6-11.

Schank, R. (1997). Virtual Learning: A Revolutionary Approach to Building a Highly Skilled Workforce. New York, McGraw-Hill.

Senge, P. (1995). The fifth discipline, Doubleday Dell Publ. Group.

Shneiderman, B. (1998). "Relate-Create-Donate: a teaching/learning philosophy for the cyber-generation." Computers & Education 31(1): 25-39.

Silén, C., S. Normann and I. Sandén (1993). Problembaserad inlärning - en beskrivning av ideologi och pedagogisk referenram. Linköping, Vårdhögskolan.

Simonsen, J. (1994). Designing Systems in and Organizational Context - An Explorative Study of Theoretical, Methodological, Organizational Issues from Action research to Three Design Projects. Roskilde, Denmark, Department of Computer Science, Roskilde University.

Skinner, F. B. (1968). Undervisningsteknologi. Stockholm, Almquist & Wiksell.

Slavin, R. E. (1990). Cooperative Learning: Theory, Research, and Practice. Engelwood Cliffs, NJ, Prentice Hall.

Soloway, E. (1993). "Technology in Education." Communications of the ACM 36(5): 28-30.

Stolterman, E. (1995). "Information systems research and social responsibility." Scandinavian Journal of Information Systems 7(1): 123-128.

Watson, J. (1996). Reflection Through Interaction: The Classroom Experience of Pupils with Learning Difficulties. London, The Falmer Press.

Weber, R. P. (1985). Basic content analysis, Sage publications, Inc.

Ågren, P.-O. (1997). IT i högre utbildning: rationalisering eller pedagogoik? IT i universitetsundervisningen. P.-O. Ågren. Umeå, Umeå universitet: 5-16.

First Paper

What about failures?

Suggestions for an alternative computing education activity

Urban Nuldén and Helana Scheepers

Abstract

In computing education, students are given some real life experience of the development of computer systems. This experience does not usually include project failure and especially not escalation situations with difficult decisions that deepen or compound the problems a project has. We argue that the only way in which students will be able to recognize escalation is by actually experiencing a project that is escalating and that will fail. In the first part of the paper escalation and the determinants of escalation are discussed, this is followed by a description of the experiment conducted and the results. From the results of the experiment we conclude that students act in the same way as practitioners do. We claim that if we do not change the way in which students are taught, we perpetuate the problem. We end the paper with ideas about how to change computing education to make students aware of, but also make them understand the problem of escalation situations.

1. Introduction

This paper presents an experimental survey conducted to examine how students act in a problematic computing project situation. We hold that the majority of all computing projects undertaken have problems of some kind (e.g., Brooks 1975). Whereas there are many different types of computing project problems, this research is about those computing projects that never seem to end—they become runaways (Keil 1995a). This is a dangerous phenomenon costing organizations millions of dollars each year; both in direct losses and missed opportunities. A project can be described as a runaway when more and more resources are invested despite information indicating that the project probably will fail in meeting the expectations of the stakeholders. In this paper it is assumed that it is possible to denote a project as a failure, even though it is not always apparent (Lyytinen and Hirschheim 1987). However, we claim that the awareness of runaways are crucial for both information technology experts and end users who often are central actors in systems development projects.

A runaway project is an escalation situation (Staw and Ross 1987a) and can be described in the following framework: All escalation situations entail some loss or cost as a result of an original course of action, the situations involve some continuity over time, a simple withdrawal is not an obvious solution, the decision maker must have a real choice in deciding whether to persist or withdraw, uncertainty of goal attainment and unambiguous feedback from previous decisions made. Escalation situations emerge through a complex compound of psychological, social, organizational, and project determinants.

Experimental research similar to the research presented in this paper has been done in the US (Schneider 1993; Sabherwal, Sein et al. 1994; Keil, Mixon et al. 1995). In this research, a scenario of a computing project was presented to two groups of undergraduate computing majors who were asked to act as project managers. As the scenario of the project progressed it experienced problems. The task of the subjects was to identify the problems and recommend to top management how to proceed with the project. The responses in the survey were analyzed through the escalation framework. The paper concludes that though most of the subjects stated that the project was in trouble, they were convinced that the right decision was to invest more resources and let the project continue. From the result

of the study, we argue that runaway computing projects must receive more attention in computing education. We do note that most organizational behavior courses, and similar courses given at, for instance, business schools, do include aspects of runaways and escalation. However, we question current traditional pedagogical principles of knowledge transfer as an appropriate mode of creating an understanding and eventually teaching about how to avoid runaways. The paper closes with some suggestions on how escalation situations can be integrated in computing education.

The remainder of the paper is organized in the following six sections: The first section "Escalation situations" explains and discusses different aspects of escalation. The following section, "Subjects and research design" presents the subjects and the scenario used in this research. The next section, "Analyzing the survey" applies the escalation framework from section two to analyze the survey. The analysis is followed by a discussion section. In section six educational practice is discussed in the light of the findings in our study. Finally, in "Concluding remarks and further research" we show some practical implications for computing education and outline our further research.

2. Escalation Situations

Research on escalation situations during the past 20 years has consisted mostly of experiments in psychology and sociology under the headings: *knee deep in the big muddy* (Staw 1976), *entrapment* (Fox and Staw 1979; Brockner, Nathanson et al. 1984), *too much invested to quit* (Teger 1980), *escalation of commitment* (Staw and Fox 1977; Staw 1981; Staw and Ross 1987a), *knowing when to pull the plug* (Staw and Ross 1987b), *throwing good money after bad* (Garland 1990). The escalation research has only recently moved into a computing context (Schneider 1993; Sabherwal, Sein et al. 1994; Keil, Mixon et al. 1995). However, different types of failing projects and remedies against failures have been discussed and suggested since the beginning of computing (Brooks 1975). In the following we describe escalation situations and explain how they emerge.

2.1. Characterizing Escalation Situations

An escalation situation can be thought of as a situation where decision makers have continued commitment to a specific course of action despite information suggesting that the course of action is failing (Staw 1981; Staw

and Ross 1987a), and even invest more resources (Fox and Staw 1979). Brockner (1992) elaborates this further by arguing that an escalation situation is continued commitment in the face of negative information about prior resource allocations coupled with "uncertainty surrounding the likelihood of goal attainment." Decision-makers become locked into an escalation situation through what Staw (1981; 1982) calls a "syndrome of decision errors." Bowen (1987) criticizes this and argues that commitment to a further investment occurs because of the equivocality in the situation and not because of an over-commitment to a failed decision. He continues that one can not "technically" err in an ill-structured decision situation.

Commitment, as the central concept in escalation situations, has as such been studied from so many different theoretical perspectives that some argue that the concept should be abandoned in favor of a set of terms (Angle and Perry 1981). Commitment has for instance been described as: the state of mind that holds individuals in a line of behavior (Salancik 1977), the binding of an individual to behavioral acts (Kiesler 1971) and an active counterforce to change (Staw 1982). Commitment, in this paper, is not necessarily good or bad, but the level of commitment of various individuals in a project will greatly influence the eventual success of the project. Without commitment one really does not have a project.

When commitment induces a person to complete a difficult or unpleasant task that benefits him and others, commitment is good. Obviously, without commitment the hard work required will not be done. However, when commitment leads to a fixation on a policy or behavior of diminishing benefit and rising cost, the situation is obviously problematic.

All escalation situations have characteristics that can be isolated and described in the following framework (Staw and Ross 1987a): (1) they entail some loss or cost—not necessarily monetary—that has resulted from an original course of action, (2) the situation involves some continuity over time—they are not once off affairs, but dilemmas involving ongoing courses of action, and (3) they are situations where a simple withdrawal is not an obvious solution. Moreover, (4) the decision-maker must have a real choice in deciding whether to persist or withdraw (Brockner 1992), (5) there must be unambiguous feedback from previous decisions made (Bowen 1987), and (6) there is uncertainty of goal attainment.

2.2. Emergence of Escalation Situations

Not to lose the essence of how escalation situations emerge; attention should be shifted away from identifying the isolated antecedents of escalation situations and toward analyzing the influence of more general classes of determinants. Staw and Ross (1987a) propose a model for analyzing and understanding the emergence of escalation situations in which they suggest four abstract classes of determinants for escalation situations: project determinants; psychological determinants; social determinants; and organizational determinants (figure 1). We will discuss each of these determinants below.

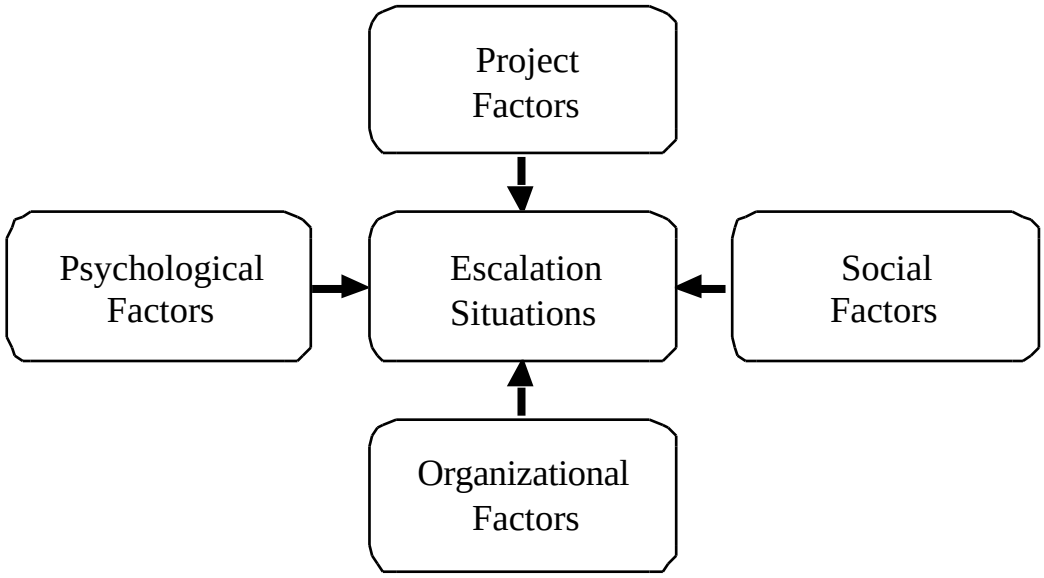

Figure 1: Emergence of escalation situations

The effect each of the determinants will have on different stages of the project is discussed in e.g., Newman and Sabherval (1996), but further research is required. Also, the interrelationships among the four determinants need to be further examined. However these two issues are beyond the scope of this paper.

2.2.1. Project Determinants

Project determinants are the objective attributes of a project—mostly economic, such as the project's benefits and costs (Brockner 1992). A project is likely to be continued with high commitment even when it is facing problems, if the project is perceived as a long-term investment, expected to have a large payoff, and/or have a long-term payoff structure (Sabherwal, Sein et al. 1994). High commitment is also likely to occur

when closing costs are high and salvage value is low (Staw and Ross 1987b).

2.2.2. Psychological Determinants

Psychological determinants cause individuals to see situations from a promising and optimistic view (Brockner 1992). They explain, to some extent, managers' unwillingness to admit that an earlier decision was wrong (Staw and Ross 1987a). Underlying psychological theories explaining escalation situations are according to Keil, Mixon et al. (1995): self justification theory—when an individual desires to demonstrate rationality to himself—and prospect theory—when individuals exhibit risk averting or risk seeking behavior depending on how a problem or decision situation is framed. "Throwing good money after bad" in an attempt to turn around a failing situation, the so-called "sunk cost" effect, is another example (Arkes and Blumer 1985; Garland 1990).

2.2.3. Social Determinants

Social determinants hold the individual to a course of action regardless of the individual's own beliefs. Examples are face saving and external justification . Social comparison theory posits that people are concerned with evaluating the appropriateness of their attitudes and behavior. People regard the behavior of others as a model for their own behavior and this occurs when they are uncertain about the appropriateness of their own attitudes or behavior . Social determinants also involve a group's relation to another group and a successful effort by a group may influence other groups to attempt the same approach. This is often referred to as benchmarking.

2.2.4. Organizational Determinants

Organizational determinants are the structural, cultural and political environment of a project, for example, top management support, administrative inertia, and interorganizational interaction. According to Keil (1995b) projects are more prone to escalate when there is strong political support and when projects become institutionalized. Institutionalization occurs when a project is tied integrally to the values and purposes of the organization, and when actions are taken for granted because they are so deeply imbedded in the subculture or norms of the organization. Long-standing programs and lines of business are not even

considered for discontinuation because they are so closely identified with the organization.

2.3. Avoiding Escalation Situations

Contemporary research on organizational behavior and systems development suggests that escalation situations or runaways projects can be avoided. These suggestions focus on three aspects:

- **The Aspect of Professionalism. All IT professionals have ethical duties when it comes to reporting on the status of a project (Anderson, Johnson et al. 1993; Smith and Keil 1995; Smith and Keil 1995). Project managers, and other decision makers, must recognize that there is a natural tendency to escalate when one becomes too committed to a course of action. If project managers are aware of other escalation situations and the forces "driving" persistence and "restraining" withdrawal in the situation, their propensity to escalate in the next project is probably lower.**
- **The Aspect of Decision Processes. The project manager must ensure that as many decisions as possible are subject for discussion, e.g., no decision should be made without explicit consideration of the disadvantages or risks involved in the decision alternative. Negative aspects must be surfaced in all decisions to be made. If no negative aspects are found, postpone the decision until the next day or the next meeting. Since the final decision to continue a failing project often is made by an individual, the process leading to the decision should be a group effort (Schneider 1993). For this, conflict is a mechanism for facilitating learning, e.g., by the use of a devil's advocate, an individual who plays the formal role of a critic to help the decision maker test the assumptions and the logic of the ultimate decision. The importance of the group in the decision process is further emphasized since many decisions made in projects concern problems which are not well defined, i.e., soft problems (Checkland 1981), and have to be discussed from many perspectives.**
- **The Aspect of Organizational Culture. Organizations should, to a greater extent, use formal methods to monitor the progress of projects. Serious project audits must be executed on a regular basis. Larger projects have a higher risk for escalation and a greater need for control. These large projects have higher complexity, more**

stakeholders with different views and criteria for success, greater resource requirements, greater scope and more interactions resulting in more opportunities for inadequacy. Different reactive activities, such as indicators, evaluation, control and assessments are important management issues in project activities. Most organizations have monitoring functions to control deviations in projects, and functions are added to monitor the functions and so on (a common way to control what is not under control). But, no matter how thorough the control, audits and revisions are, it is possible to hide all problems , until it is too late to deal with them. Therefore, a proactive approach to avoid escalation is necessary. With an explicit company policy on failure people in the organization have guidelines for how to act in an escalation situation. An attitude such as "*we have never abandoned any project in this organization*" will surely promote escalation. A central issue in a proactive approach is incentives, such as rewards for project members as well as corrective action when called for. Organizations have to create such an open environment or culture in which individuals and groups are forced to raise the questions necessary to avoid project escalation.

3. Subjects and Research Design

This section presents the two groups of students and summarizes the scenario presented to the subjects. The two groups come from Sweden and South Africa. The reason for this is partly practical since this is where the authors live, but the research presented in this paper is also part of a larger research effort where the heterogeneity of the South African society and the homogeneity of the Swedish society respectively are studied in more depth. This is however not reported in this paper.

3.1. The Subjects

The first group of student subjects consisted of 47 first year undergraduates in a four year computing program at a Swedish University. The researcher visited a lecture and asked the students to devote 30 minutes to a "decision making study." No extra credits or other incentives were offered. 10 of the subjects were female and 37 were male. 5 students decided not to participate in the survey. The average age was 24 years and they had an average of 3 years of work experience.

The second group consisted of 70 second year undergraduates in a three year information systems program at a South African University. The researcher obtained permission to conduct a survey about the project described in the scenario. No extra credits or other incentives were offered. Of the subjects 26 were female and 43 were male, 1 student did not identify his/her sex. One student decided not to participate in the survey. The average age was 20 years and they had an average of 6 months work experience.

3.2 The Scenario

This section summarizes the scenario presented to the subjects. They were asked to play the role of a manager and make decisions about a systems development project in a large pharmaceutical company, MedPro. The scenario was originally written in English and later translated into Afrikaans and Swedish. This might have introduced differences in the text. As a comparison of the two groups was not initially the main focus of this study we did not see this as a major problem. However, retrospectively we believe it would have been more appropriate to use English as the only language for surveying the students as both groups of students have complete mastery of English.

In 1994, the research division of MedPro discovered a very effective new drug for rheumatism. The laboratory tests on the drug were completed late in 1994, and the tests on humans could begin. Testing of new drugs is a regulated task and the FDA has very strict rules for conducting tests on humans. *Your* systems development group has recently designed a prototype of a computer-based system that will both shorten the testing, and improve the quality of the test documentation. Therefore, the CIO at MedPro has recently granted $5 million for the development of the proposed system, TEST.

Shortening the test phase means that the rheumatism drug will be on the market earlier, and MedPro will increase their profit and they will obtain a large share of the market before any competitor will be able to enter the same market. The president of MedPro has indicated strong support for the project in the company magazine: "This is the kind of project our organization needs to maintain our position at the top of the market."

Four years ago, another systems development group designed a very effective system for the marketing and distribution division. Their system has, by all means, contributed to MedPro's position as an efficient distributor of drugs on the world market.

As MedPro is mainly a research organization, the organizational culture is very forgiving when it comes to errors and it is believed that it is necessary to take risks to learn, invent, and discover. *You* are confident that the system will be a real success and have spent a great deal of time discussing the benefits of TEST with departmental colleagues. *You* also bring up TEST as a subject to get the test division researchers' opinions and suggestions. The test and manufacturing division will shorten the test phase by 50 per cent. The new rheumatism drug will be on the market two years earlier than with the old procedure. Introducing the drug on the market even one year earlier would mean an additional estimated $8 million in profit. MedPro is very dependent on information technology to maintain its position as world leader within drug development.

The analysis and specification were completed on schedule in June 1995. The development phase started shortly afterward with a planned implementation date of November 1995. The test and manufacturing division has put a lot of faith in the new system and has decided to postpone the start of tests on humans until the computer system is implemented. The manual testing procedure is fundamentally different from the new computer-based procedure. It would be very costly to transform results either way.

During the first month of the TEST project, medical press announced that another pharmaceutical company had discovered an effective new substance for treating rheumatism. Their product has shown excellent results in laboratory tests but the competitor has not started tests with humans yet. However, they will start shortly.

Additional personnel should be hired and extensive training is needed to adequately staff the TEST project. Investment in new hardware is required for the TEST system. Furthermore, the TEST system should be compatible with other applications in MedPro, both existing and planned systems. The project team has also tried to ensure that TEST, after some modifications, probably can be used in administrating testing of future drugs, but this has not been fully investigated yet.

Minor problems have surfaced in the project group since the first week. Communication among the project staff has not been satisfactory

due to interpersonal conflicts, which resulted in the project being split into two groups after the first month of the project. *You* believed that this problem would resolve itself over time, but instead it has become worse. In October, one month before the planned implementation, the project runs into severe difficulties: the program code is a mess according to an external auditor, and many of the assumptions made in the analysis phase are no longer valid. Large parts of the analysis must be redone, and at least three man months of coding must be repeated. The original implementation date will not be met. Instead, an additional three months is needed to complete the project.

Two additional programmers join the team to handle the problems, but the three months pass and the problems are still not solved. One of the most experienced programmers in the project group finds a 'bug' in the database manager, and assures you that he will fix the problem in one month. Writing the new code takes longer than first anticipated and the project needs an additional three months to be completed and an additional 50 per cent funding is needed to hire two top programmers to structure the code. Senior management are worried and as MedPro's CIO is aware of the problems TEST has encountered he calls an additional meeting in late March 1996. *You* are asked to prepare a short presentation on your preferences for this project's future.

4. Analyzing the Survey

In this section, the survey is analyzed using the escalation framework discussed in a previous section. The mode of analysis in this research was interpretive content analysis (Patton 1990) and the instrument applied in the survey focused on two issues. Firstly, subjects were asked to indicate their comprehension of the problems on a 7 point Likert scale ranging from '*no problems*' (1) to '*big problems*' (7). Secondly, they were asked if the project should be abandoned, this also on a 7 point Likert scale ranging from '*absolutely*' (1*)* to '*absolutely not*' (7). Each of these questions was followed by an open ended question where the subjects were asked to describe the problems as they saw them, and motivate their decision about abandonment or continuation of the project.

The following methodology was used for the categorization of problems and reasons for continuation for the open ended questions as identified by Weber (1985). The basic unit used for the classification of the written

answers of the students were phrases that could be a whole sentence or part of a sentence. The way in which a phrase was identified was a group of words describing a specific problem or reason for continuation. Each phrase was classified in one and only one problem group for the problem question or in one and only one determinant category for the abandonment question.

The categories into which the problems were categorized were identified after a preliminary investigation of the answers that were given by the students. Formal definitions were written for the problem categories by using systems development textbooks. The four determinants identified in section two were used as categories for the abandonment of the project. It was necessary to define these determinants in terms of the MedPro case study.

The responses of the students were coded by the authors and by independent researchers. The above mentioned definitions as well as the unit for coding were given to the researchers. The coding by the researchers was compared and any problems with the coding was solved by revising the definitions for each of the categories. The two South African researchers coded the South African students' responses and two Swedish researchers coded the Swedish students' responses. This was done because of the language used by the students in responding to the questions. The reliability, in terms of stability and reproducibility of the result, was ensured by using two researchers for the coding and comparing of the results of the questionnaire.

4.1. Descriptive Analysis of the Perceived Problem

	Mean	SD	Min.	Max.
Sweden (n=47)	4.79	1.07	2	7
South Africa (n=70)	4.96	0.94	2	7

Table 1: Statistics on subjects' comprehension of problems in the project. We interpret this as there are no significant difference in how the two groups perceived the problems. The variation is also, as we interpret it, equal in the two groups.

The following definitions were used to code the open ended question on the subjects' comprehension of the problem, or problems, in the scenario.

1)Time: an indication that the project is taking longer in time than planned, or phrases that refer to the allocation of more time to complete the project.

2)Planning, analysis and design problems: refers to mistakes made in the planning and analysis phases of the project.

3)Economic problems: an indication that the project is over budget or that given more money the project will be successful.

4)Technical problems: refers to software development problems or hardware problems, it could also refer to problems with the programming of the system (not with people).

5)Staffing problems: refers to the experience of group members and the composition of the group members.

6)Communication problems: refers to poor communication and cooperation among group members and between group members and users.

7)Environmental: refers to competing organizations in the same industry.

4.1.1. Swedish Subjects

This section summarizes the Swedish subjects comprehension of the problems presented in the scenario. The problems are listed in decreasing order and supplemented with anecdotal comments from the students.

1. **Time was the major problem according to 57 % of the Swedish subjects. The subjects used the following statements to articulate this: "*Actions are dragging out, promised deadlines are not kept.*" Or, "*The fact that the project is slipping—time is also a big problem.*"**
2. **The second largest problem was communication problems according to 53% of the subjects. "*The project group has problems in working in the same direction and toward the overall goal.*" Others found that: "*Conflicts between people is the biggest problem.*" Whereas others asserted that "*all problems could have been avoided if the conflicts were handled in the beginning.*"**
3. **Planning, analysis, and design problems were stated by 45% of the subjects in terms such as: "*There are no alternative solutions in case something should become problematic.*" Moreover, "*There were some mistakes made in the early work, the analysis. This resulted in big***

***problems in the later phases.*" Others were less certain: "*Non-anticipated problems showed, does this depend on poor planning?*"**

4. **Technical problems were indicated by 36% of the subjects. "*There have been some programming problems that must be considered before TEST can be put to use.*" Moreover, "*Bugs are found, this will take some time to fix. The code must be improved.*"**
5. **Economic problems were also perceived by 36% of the subjects. The following assertions were made: "*They must have TEST running as soon as possible to increase the profit for MedPro.*" Or as losing money: "*Several months delay is eating the profit.*"**
6. **Staffing problems was perceived by 23% of the subjects. Statements such as the following were used: "*If the right people had been in the project from the very beginning, the problems might have been smaller.*" Other subjects saw that: "*People's competence is overlooked,*" and "*Project management is weak since the members' potential is not utilized.*"**
7. **Environmental aspects were identified by 9% of the Swedish subjects. The approaching competitor was stated in phrases such as: "*If other medical companies come before our project is in place, the project will not have gained anything.*"**

4.1.2. South African Subjects

This section summarizes the South African subjects' comprehension of the problems presented in the scenario:

1. **Communication problems were the major problem according to the South African subjects with 70% identifying it as a problem. They stated for instance: "*Bad communication between team members*", "*Communication problems*", "*The team should work as a unit*" and "*The project team does not work together.*"**
2. **Time was the second largest problem with 64% of the subjects identifying it as such. They stated for instance: "*Additional time is necessary*" and "*The project is taking more time than planned for.*"**
3. **Three factors received the same number of comments by the respondents. Economic problems, Technical problems and Planning, analysis and design problems each received 41%.**
   a) **Statements that were classified as economic problems were: "*Need some more capital to finish the project*" and "*Over budget.*"**

b) Typical technical problems statements were: "*The software has too many problems/bugs*" and "*Badly structured programs. Bad programming.*"

c) Planning, analysis and design problems were identified by statements such as: "*It seems as if the planning phase has not been completed*" and "*Wrong assumptions made during the analysis phase.*"

4. **Environmental aspects were stated as a problem by 31% of the subjects, with statements like: "*There is already another company that have announced that they have a rheumatism product*" and "*Market share will shrink if we do not continue.*"**
5. **Staffing problems were identified by 21% of the subjects with statements like: "*More personnel are needed*" and "*Get more experienced programmers to do the programming*".**

4.2. Descriptive Analysis of the Motivation to Continue

	Mean	SD	Min.	Max.
Sweden (n=47)	5.55	1.29	2	7
South Africa (n=70)	4.56	1.5	1	7

Table 2: Summary statistics on subjects decision whether to abandon or continue the project. The difference in mean suggests that the Swedish subjects have a stronger tendency to suggest that the project should continue. The variation is slightly bigger with the South African subjects but not significant.

During the classification of the comments of the respondents the following three groups were identified: respondents who gave a value of 1 (that signifies that the project should definitely stop) to 3 was classified as respondents who wanted to abandon the project; respondents who specified a 4 were classified as unsure of whether the project should continue or not and respondents who specified a 5 or higher were classified as respondents who wanted the project to continue. Only respondents who were unsure or wanted to let the project to continue were used in the discussion below. The table below summarizes the responses.

	< 4	4	> 4
	Abandon	Unsure	Continue
Sweden (n=47)	2	7	38
South Africa (n=70)	13	15	42

Table 3: Summary of the preferences for the projects continuation

4.2.1. Swedish Subjects

In the section project abandonment was suggested as an alternative course of action, only two (4%) of the Swedish subjects suggested that the project should be stopped (gave it a value < 4). Seven (15%) of the subjects gave it a 4 which we interpret as uncertainty as to whether to continue or to abandon the project. Finally, 38 (81%) of the subjects gave it a value of 4 or greater. The motivations stated to continue the project from the Swedish subjects were as follows in decreasing order:

1. **Of the Swedish subjects, 62% motivated the decision with project factors. The strongest was the view of long-term investment. *"Even if it takes longer than planned, it will be a valuable resource in the future. The company will make a lot of money in the future."* Or similarly, *"The future profits are substantial."***
2. **33% motivated project continuation according to the psychological determinants. The strongest psychological factor was, as expected, sunk cost. For instance, *"$35 million would be wasted if the project is abandoned."* Or in a similar way: *"If the project is canceled now, we would have nothing at a very high cost."* Self-justification was also a common psychological factor: *"I have strong confidence in the project since I manage it, and I hate to fail."***
3. **Organizational determinants also occurred in 33% of the motivations: *"If top management finds the system that important then the system is worth the extra money and time needed, and they are confident that the cooperation among the actors will work, they should continue the project. To me, it seems to be too expensive and will take too long to complete."***
4. **Only 2 out of 45 or 4% had motivations belonging to social determinants. This was also expected since we find these types of**

determinants very difficult to manipulate in this type of experiment. However, we found external justification, such as "*An abandonment would send negative signals. There was a lot of publicity before the project started and I want to save my face.*"

Seven (15%) of the Swedish subjects gave no answer or an answer not related to any of the four determinants. One of the subjects suggesting that the project should be abandoned very rationally stated that: "*Projects slipping in time have a tendency never to get completed.*"

4.2.2. South African Subjects

In the project abandonment section of the questionnaire 13 (19%) of the South African subjects suggested that the project should be stopped (gave it a value < 4). Fifteen (21%) of the subjects gave it a 4, and 42 (60%) of the subjects gave it a value of 4 or greater. The motivation for the South African subjects was as follows:

1. **Of the subjects, 66% motivated project factors. Long term investments were named as the main reason with statements such as: "*Even if it takes longer to implement the project the long term effect of profitability still exists*" and "*This project can be used for other drugs as well.*"**
2. **13% gave motivations of a psychological nature. The strongest psychological factor was sunk cost, with remarks such as: "*Too much money and time has been spent to stop the project now*." Self justification was also a common factor: "*We will still be able to make a success of this project,*" "*The project is nearly finished and we will still be able to be successful*" and "*We tried and we learned a lot*."**
3. **Of the subjects, 13% named organizational determinants as a motivation to continue the project. Statements such as the following were used: "*The competition should be taken into consideration. We should not stop the project now, else we will lose market share*" and "*Management is behind the project.*"**
4. **Social determinants were identified by 7% of the subjects with statements such as: "*Work with the group rather than sending them away*" and "*If we work together and communicate we can finish this project quickly*."**

Nineteen (27%) of the subjects gave no answer or the answer could not be related to any of the four determinants.

4.3. Inferential Analysis

During the statistical analysis the classification of the comments on the problems and the continuation of the project were divided into two groups each to ensure the validity of the χ^2 test. The groups for problems were: respondents who gave a value of 1 to 4 were classified as respondents who identified no problems or were indifferent about the problems (No) and respondents who gave values of 5 to 7 were classified as respondents who identified problems (Yes). The groups for continuation of the project were: respondents who gave a value of 1 to 4 were classified as respondents who did not want to continue with the project or were indifferent to the continuation (No) and respondents who gave values of 5 to 7 were classified as respondents who wanted to continue with the project (Yes). Table 4 below identifies the combined values after the reduction.

Problem	Yes	South Africa	27	23	
		Sweden	25	8	
		Total	52	31	Total: 83
	No	South Africa	16	4	
		Sweden	12	2	
		Total	28	6	Total: 34
			No	Yes	Total: 117
			Continue project		

Table 4: Summary of statistical analysis

The following hypotheses were tested:

1. Across both samples, when students were positive about the problems did they then specify that the project should continue (thus did they opt for continuation of the project)?

H_0: There is no relationship between the identification of a problem and the identification of continuation.

H_1: There is a relationship between the identification of a problem and the identification of continuation.

Performing a χ^2 test (5% significance level) the null hypothesis was rejected ($\chi^2 = 4.32998$). There seems to be a relationship between problems / continuation and students that identified a positive value for problems will also give a positive value for continuation.

2. Is there a correspondence between the proportion of students that identified problems (Yes to problems in the table above) between the South African and Swedish samples?

H_0: The proportion of students who were positive about the problems (Yes to problems in the table above) is the same for Sweden and South Africa.

H_1 : The proportion of students who were positive about the problems (Yes to problems in the table above) is not the same for Sweden and South Africa.

Performing a χ^2 test (5% significance level) the null hypothesis was accepted (χ^2 = 0.020163). The proportion of students of Sweden and South Africa for the identification of problems are the same.

3. Is there a correspondence between the proportion of students that were positive about the continuation (Yes to continuation in the table above) of the project between the South African and Swedish population?

H_0: The proportion of students who were positive about the continuation of the project (Yes to continuation in the table above) is the same for Sweden and South Africa.

H_1 : There proportion of students who were positive about the continuation of the project (Yes to continuation in the table above) is not the same for Sweden and South Africa.

Performing a χ^2 test (5% significance level) the null hypothesis was rejected (χ^2 = 3.88976). The proportion of students of Sweden and South Africa for the identification of continuation is not the same. By looking at the data it can be seen that the Swedish students were more likely to continue the project than the South African students.

5. Discussion

In this research we have investigated how students perceive a scenario of a computing project with problems.

5.1. Subjects' Understanding of Problems

Rank	Swedish percentage	South African percentage
1	Time	Communication problems
2	Communication problems	Time

3	Planning, analysis and design	Planning, analysis and design Technical problems Economic problems
4	Technical problems Economic problems	Environmental aspects
5	Staffing problems	Staffing problems
6	Environmental aspects	

Table 5: Summary of understanding of problem

By comparing the order of the importance of the problems identified by the subjects, large similarities could be identified as seen in the table above. Communication problems were ranked in the first and second places respectively for the South African subjects and the Swedish subjects. Time was placed first by the Swedish subject whereas the South African subjects placed it second. Planning, analysis and design, technical problems and economical problems were placed in third and fourth position by the Swedish subjects and third by the South African subjects. Staffing problems were placed in the fifth position by both groups. The environmental aspects were placed sixth by the Swedish subjects and fourth by the South African subjects.

5.2. Subjects Motivation For or Against Continuation

When the motivation for continuation is compared, there is also a correspondence between the subjects' identification for motivation. What is different though, is the number in the percentage of subjects who wanted to abandon the project. Of the Swedish subjects, 4% thought that the project should be abandoned and 19% of the South African subjects thought that the project should be abandoned. There is a bigger tendency with South African subjects to stop the project, as they were more pessimistic about the project, 4.56 vs. 5.55 in motivation to continue.

The differences as outlined above can be explained by the differences in work experience as well as the theoretical background. The differences can also be ascribed to the different cultural backgrounds of the subjects. South African students are part of a changing society with a very big possibility of conflict between differences in values and beliefs of the heterogeneous groups whereas the Swedish students are part of a homogeneous society with established values and beliefs.

However, our main finding in this research is that the subjects perceived that the project had problems, but were still convinced that the project should be continued. This result is consistent with case studies (e.g., Keil 1995b; Newman and Sabherval 1996) and other experimental surveys (e.g., Schneider 1993; Sabherwal, Sein et al. 1994; Keil, Mixon et al. 1995). Therefore we conclude that education must include escalation situations and the next section is an example of how this can be done.

6. Educational Practice

Reflecting on educational practice in general, we claim that pedagogical principles underlying most educational activities will not address the phenomenon of escalation efficiently. Text books used in systems development, project management and organizational behavior courses have a line or two about escalation situations. We claim that it is not enough. From this perspective, we discuss education principles and practice, however it should be clear that an extensive pedagogical discussion about educational practice is not within the scope of this paper.

Looking at higher education, the most frequently used method of teaching is the lecture. The traditional lecture implicitly embeds an *objectivistic model* of learning (Leidner and Jarvenpaa 1995). That is, the purpose of teaching is to structure the knowledge to be learned and transfer this to passive students through effective channels. The instructor is active and in control of the learning material and the environment where learning is taking place. Information is transmitted to students with little concern for whether the students understand or assimilate the information transferred (Leidner and Fuller 1996). Assessment and examinations are conducted to determine whether content have been retained (Margretson 1991). The objectivistic model may be appropriate in some educational activities, but we claim it is insufficient in the case of escalation situations. As a contrast and alternative, the *constructivistic model* of learning asserts that rather than transmitted, knowledge is constructed or created. Learners are assumed to learn when they are forced to discover things themselves and not by being instructed. The role of the educator is to facilitate the learning process and support the students in the construction of their knowledge (Slavin 1990).

Whereas objectivism and constructivism is concerned with the individual learner, a *collaborativistic model* assumes that control of

learning should rest with a group of learners. Similar to constructivism, collaborativism asserts that learners construct knowledge by making sense in terms of what they already know but also in interaction with other learners (Slavin 1990). This way, learning is the sharing of knowledge from individual views through collaboration. Whereas instructor-led learning is inherently a linear and predictable process, collaborative groups ensure a more unpredictable process. We also claim it to be a more enriched learning experience. The importance of experience in learning is recognized by Graf and Kellogg (1990) and by Kolb (1976) in his learning cycle which begins with a concrete experience (see figure 2).

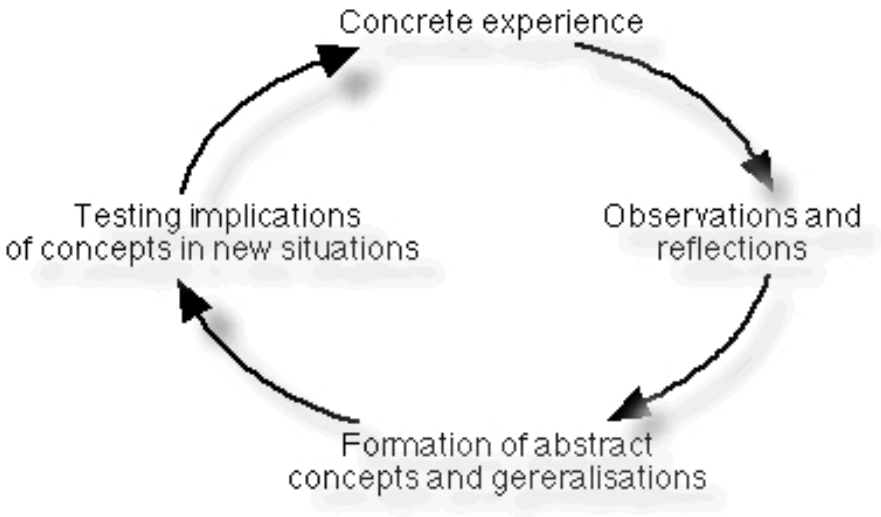

Figure 2: Kolbs model of the learning cycle

In experiential learning the basic underlying principle is that the best learning is by doing—*learning-by-doing* (Graf and Kellogg 1990). A similar understanding is proposed as—*learning-in-doing* (Pea 1993; Moore and Potts 1994). Examples of experiential learning are internships, computer assisted instruction, live case, case studies, role play, games and simulations.

Clearly, new pedagogics and alternative learning models fundamentally change the roles of the students and instructors (see for instance Scardamalia and Bereiter 1993; Harasim, Hiltz et al. 1995; Turoff 1995). The role of the instructor changes from the main source of information to a facilitator of the learning process. Rather than lecture information or manage behavior, teachers cultivate skills, focus effort, foster resourcefulness, and maintain an interactive climate of learning.

The expected role of the student is that of active participator in the learning process.

Moving the discussion into a systems development education context, we find several examples of collaborative learning activities. Probably the most common activity in systems development education is to divide the class into smaller project teams where each team is requested to complete a systems design and development project, which they have to develop according to the methodology they were taught. Each group has access to a lecturer or instructor who acts as their *senior project manager*. The senior project manager is there to monitor the situation and give advice if the project team has any problems. This gives the students experience in how a system is developed in a group and what problems might arise in this situation. Our main critique is that this *project team* operates in an artificial and rational environment neglecting several real world problems. However, as this critique is quite common, we here focus our interest and emphasis on the phenomenon of escalation situations.

6.1. An Alternative Systems Development Education Activity

In this section we articulate some ideas on how escalation situations can be integrated in systems development education. Experiential learning and collaborativism serve as pedagogical foundation for our discussion. Participating in a failure can be a real eye-opener for the students and one that they are likely to remember. In line with the concept of experiential learning, knowledge that is practiced is more efficiently assimilated than knowledge passively absorbed. However, with limited resources, such as time, systems development courses must provide this experience through a simulated situation. What we suggest is a role play activity in a development project where a group of students work together. It should be noted that role playing escalation experiments has been performed previously (Staw 1981).

The students should be organized in teams and the instructor should provide them with the case material in a continuous fashion throughout the process. This can be documents, models, tapes, and videotapes, all depending on the instructor's enthusiasm and time. The group plan and start the project and the instructor assures that the role play case is 'alive' by constantly supplying information about problems, changes, etc., (see box 1 below for a rough description of the process). Supplying additional

information is a delicate task for the facilitator. This demands a lot from the educator as she must create the necessary atmosphere to make this possible. The task is initially to make the group confident and make them believe their work is professionally performed, then successively let problems surface. A central aim in developing an escalation-like situation is to facilitate chained decisions, that is, the result of one set of decisions influences the rest of the decision making process.

The scenario about MedPro and TEST used to survey the students can be seen as an example of a case where the instructor supplies information as the project progresses. To keep all participants and the instructor focused and concentrated on the task we believe two hours as an appropriate length for the role play.

Step 1: Present the case to the students as a decision making task where the students are to work in groups and complete a complex project together.

Step 2: Divide into groups consisting of eight to ten students.

Step 3: Case work (there are a number of iterations of 3.1 to 3.3 facilitated by the educator).

Step 3.1: Instructor gives additional information.

Step 3.2: Group discusses situation and works with the project.

Step 3.3: Group proposes course of action.

Step 4: The students present their work with the project in a seminar. Feedback from peers and instructor.

Step 5: Debriefing by the instructor.

Box 1: Outline of role play case study framework

It is very important to debrief the group after the role playing task is completed to achieve the desired effect (Krueger and Dickson 1994). The awareness of the purpose and methodology of the experiential activity is underlined by Jones (1997). He points out the damaging effects simulations and games can have. Damaging effects might occur if the instructor does not recognize the methodological conflict in using games and simulations. Here the instructor should emphasize the purpose and the underlying principles of the role play. Otherwise there is a risk that the role play will result in the students having low self-esteem and confidence. The

debriefing discussion (step 5) with the students should be augmented by referring to the fast growing body of literature on project failures (Lucas 1975; Markus 1983; Charette 1989; McComb and Smith 1991) and especially project escalation (e.g., Staw and Ross 1987a; Keil 1995b; Keil 1995c). Emphasis should also be placed on escalation avoidance in the debriefing.

Hence, what we advocate is consistent with the underlying principle of problem based learning (PBL). The essence of PBL is the understanding and analysis of (real world) problem situations as a basis for acquiring knowledge, skills and attitudes. See for instance http://www.imsa.edu/team/cpbl/cpbl.html, or Boud and Feletti (1991) for an introduction to PBL.

The role playing can of course be enhanced by computer technology. Innovations in technology, such as multimedia, hypertext, video, Internet and virtual reality, are now impacting experiential learning. With our role play as example it is possible to design and develop a computerized version. Then, the instructor can follow the students' progress through the computerized project diary, a repository where all models of analysis, design and planning are stored, as well as all documents of the decisions made by the group. The instructor can act as the client, top management, governmental organizations, competitors, etc., by communicating information to the project. Examples of these advances in technology are the use of hypertext in teaching systems analysis and design (Kendall, Kendall et al. 1996), the use of multimedia in systems analysis case studies (Farrimond 1997), and the Cardiac Tutor (Park Wolf 1996) where the students are in middle of the emergency room.

7. Concluding Remarks

In this paper we have highlighted a neglected issue in computing education, namely the phenomenon of escalation situations. We conducted an experiment to survey how students perceive and act in a scenario of an escalating systems development project. Below is a summary of our results:

- **The conducted experiment shows that students behave consistently within the escalation framework discussed in the paper. Our analysis shows that students perceived that the project had problems, but they still recommended that the project should continue. Comments, about**

the project, made by the students are consistent with comments made in case studies (e.g., Keil 1995b). The two groups of students participating in the experiment, one from Sweden and one from South Africa, did not show any significant difference in preferences for the continuation of the project.

- **We argue for the need to integrate escalation situations into the systems development curricula. We have also argued that we do not believe that escalation situations and the consequences can be taught by traditional educational principles. We ended the paper with some tentative suggestions on how to include escalation situations in systems development education by developing a, what we would say, fun and realistic collaborative learning experience. As this study is the first in a program, our intention is to design and develop a computer based multimedia scenario according to the guidelines discussed in this paper.**
- **In this research, we have not surveyed the extensive body of literature on risk avoidance in projects such as IT projects (Boehm 1989; McComb and Smith 1991; Jones 1995). However, we suggests that this literature should be used to augment the discussions after the students have experienced the role play outlined in this paper.**
- **From an end user perspective, we find it very important to be aware of, and to some extent understand, the phenomenon of escalation situations, and how they may affect the project they are attached to in their professional work. By having this knowledge the chance of acting as a whistle blower (Near and Miceli 1995; Smith and Keil 1995a; Smith and Keil 1995b) at the right moment, is considerably higher than without this understanding.**

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9. References

Anderson, R. E., D. G. Johnson, D. Gotterbarn and J. Perrole (1993). "Using the New ACM code of ethics in decision making." Communications of the ACM 36 (2): 98-107.

Angle, H. L. and J. L. Perry (1981). "An Empirical Assessment of Organizational Commitment and Organizational Effectiveness." Administrative Science Quarterly 26 : 1-13.

Arkes, H. R. and C. Blumer (1985). "The Psychology of Sunk Cost." Organizational Behavior and Human Decision Processes 35 : 124-140.

Boehm, B. W. (1989). Software Risk Management. Los Alamitos, CA, IEEE Computer Society Press.

Boud, D. and G. Feletti, Eds. (1991). The Challenge of Problem Based Learning. London, Kogan Page Limited.

Bowen, M. G. (1987). "The Escalation Phenomenon Reconsidered: Decision Dilemmas or Decision Errors?" Academy of Management Review 12 (1): 52-66.

Brockner, J. (1992). "The Escalation of Commitment to a Falling Course of Action: Toward Theoretical Progress." Academy of Management Review 17 (1): 39-61.

Brockner, J., S. Nathanson, A. Friend, J. Harbeck, C. Samuelson, et al. (1984). "The Role of Modeling Processes in the "Knee Deep in the Big Muddy" Phenomenon." Organizational Behavior and Human Performance 33 : 77-99.

Brooks, F. P. (1975). The mythical man-month - Essays on Software Engineering, Addison-Wesley publishing Company.

Charette, R. (1989). Software Engineering Risk Analysis and Management. New York, McGraw-Hill.

Checkland, P. (1981). Systems Thinking, Systems Practice, John Wiley & sons.

Farrimond, B. (1997). Using Multimedia to Present Case Studies for Systems Analysis. The International Simulation and Gaming Yearbook Volume 5 - Research into Simulations in Education. P. Saunders and B. Cox. London, Kogan Page Limited: 135-143.

Fox, F. V. and B. M. Staw (1979). "The Trapped Administrator: Effects of Job Insecurity and Policy Resistance upon Commitment to a Course of Action." Administrative Science Quarterly 24 (September): 449-471.

Garland, H. (1990). "Throwing Good Money After Bad: The Effect of Sunk Cost on the Decision to Escalate Commitment to an Ongoing Project." Journal of Applied Psychology 75 (6): 728-731.

Graf, L. A. and C. E. Kellogg (1990). Evolution of Experiential Learning Approaches and Future Developments. Guide to Business Gaming and Experimental Learning. J. W. Gentry, Association for Business Simulation and Experiential Learning.

Harasim, L., R. Hiltz, L. Teles and M. Turoff (1995). Learning Networks - A Field Guide to Teaching and Learning Online, The MIT Press.

Jones, C. (1995). "Risk of Software System Failure or Disaster." American Programmer 8 (3): 2-9.

Jones, K. (1997). Damage caused by simulation/games. The International Simulation and Gaming Yearbook Volume 5 - Research into Simulations in Education. P. Saunders and B. Cox. London, Kogan Page Limited: 11-21.

Keil, M. (1995a). "Identifying and Preventing Runaway Systems Project." American Programmer 8 (3): 16-22.

Keil, M. (1995b). "Pulling the Plug: Software Project Management and the Problem of Project Escalation." MIS Quarterly 19 (4).

Keil, M. (1995c). Escalation of Commitment in Information Systems Development: A Comparison of Three Theories. 1995 Academy of Management Best Papers Proceedings.

Keil, M., R. Mixon, T. Saarinen and V. Tuunainen (1995). "Understanding Runaway Information Technology Projects: Results from an International Research Program Based on Escalation Theory." Journal of Management Information Systems 11 (3): 65-85.

Kendall, J. E., K. E. Kendall, R. L. Baskerville and R. J. Barnes (1996). "An Empirical Comparison of a Hypertext-Based System Analysis Case With Conventional Cases and Role Playing." DATA BASE 27 (1): 58-77.

Kiesler, C. A. (1971). The Psychology of Commitment: Experiments Linking Behavior to Belief. New York, Academic Press.

Kolb, D. (1976). "Management and the Learning Process." California Management Review 13 (3): 21-31.

Krueger, N. and P. R. Dickson (1994). "How Believing in Ourselves Increases Risk Taking: Perceived Self-Efficacy and Opportunity Recognition." Decision Science 25 (3): 385-400.

Leidner, D. E. and M. A. Fuller (1996). Improving Student Processing and Assimilation of Conceptual Information: GSS-Supported Collaborative Learning vs. Individual Constructive Learning. The 29th Annual Hawaii International Conference on Systems Science, Hawaii.

Leidner, D. E. and S. L. Jarvenpaa (1995). "The Use of Information Technology to Enhance Management School Education: A theoretical View." MIS Quartely 19 (3): 265-291.

Lucas, H. C., Jr. (1975). Why Information Systems Fail. New York, Columbia University Press.

Lyytinen, K. and R. Hirschheim (1987). Information Systems Failures - a survey and classification of the empirical literature. Oxford Surveys in Information Technology, Oxford University Press. 4: 257-309.

Margretson, D. (1991). Why is Problem-based Learning a Challenge? The Challenge of Problem Based Learning. D. Boud and G. Feletti. London, Kogan Page Limited: 42-50.

Markus, L. (1983). "Power, Politics, and MIS Implementation." Communications of the ACM 26 (6): 430-444.

McComb, D. and J. Y. Smith (1991). "Systems Project Failure: The Heuristics of Risk." Journal of Information Systems Management (Winter): 25-34.

Moore, M. and C. Potts (1994). Learning by Doing: Experiences of Two Software Engineering Project Courses. Software Engineering Education 7th SEI CSEE Conference, San Antonio, Texas, USA, Springer-Verlag.

Near, J. P. and M. P. Miceli (1995). "Effective Whistle-Blowing." Academy of Management Review 20 (3): 679-708.

Newman, M. and R. Sabherval (1996). "Determinants of Commitment to Information Systems Development: A Longitudinal Investigation." MIS Quarterly 20 (1): 23-54.

Park Wolf, B. (1996). "Intelligent Multimedia Tutoring System." Communications of the ACM 39 (4): 30-31.

Patton, M. Q. (1990). Qualitative evaluation and research methods, SAGE Publications, Inc.

Pea, R. D. (1993). "The Collaborative Visualization Project." Communications of the ACM 36 (5): 60-63.

Sabherwal, R., M. K. Sein and G. Marakas (1994). Why Organizations Increase Commitment to Failing Information Systems Projects? Miami, FL, Department of Decision Science and Information Systems: WP

Salancik, G. R. (1977). Commitment and the Control of Organizational Behavior and Belief. New Directions in Organizational Behavior. B. M. Staw and G. R. Salancik. Chicago, St. Clair Press: 1-54.

Scardamalia, M. and C. Bereiter (1993). "Technologies for Knowledge-building Discourse." Communications of the ACM 36 (5): 37-41.

Schneider, G. P. (1993). Escalation Behavior in Information Systems Development: Alternative Motivations, Experience, and the Sunk Cost Effect. business Administration. Knoxville, Tennessee, The University of Knoxville, Tennessee: Dissertation

Slavin, R. E. (1990). Cooperative Learning: Theory, Research, and Practice. Engelwood Cliffs, NJ, Prentice Hall.

Smith, H. J. and M. Keil (1995a). "Mum's the Word." Beyond Computing (June): 16-17.

Smith, H. J. and M. Keil (1995b). "Speaking Out to Outsiders." Beyond Computing (July/August): 20-21.

Staw, B. M. (1976). "Knee-Deep in the Big Muddy: A Study of Escalating Commitment to a Chosen Course of Action." Organizational Behavior and Human Resourses 16 : 27-44.

Staw, B. M. (1981). "The Escalation of Commitment To a Course of Action." Academy of Management Review 6 (4): 577-587.

Staw, B. M. (1982). Counterforces to Change. Change in Organizations. P. S. G. Associates. San Francisco, CA, Jossey-Bass: 87-121.

Staw, B. M. and F. V. Fox (1977). "Escalation: The Determinants of Commitment to a Chosen Course of Action." Human Relations 30 (5): 431-450.

Staw, B. M. and J. Ross (1987a). Behavior in Escalation Situations: Antecedents, Prototypes, and Solutions. Research in Organizational Behavior. L. L. Cummings and B. M. Staw. Greenwich, Conneticut, JAI PRESS INC. 9: 39-78.

Staw, B. M. and J. Ross (1987b). "Knowing when to pull the plug." Harvard Business Review 65 (2): 68-74.

Teger, A. I. (1980). Too Much Invested To Quit. New York, Pergamon Press.

Turoff, M. (1995). Designing a Virtual Classroom. 1995 International Conference on Computer Assisted Instruction, ICCAI'95, National Chiao Tung University, Hsinchu, Taiwan.

Weber, R. P. (1985). Basic content analysis, Sage publications, Inc.

Second Paper

Needed: An Alternative Approach to Prepare Information Technology Professionals

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Abstract

This paper reports from a pilot project where a number of traditional lectures in an introductory course in information systems development were replaced by interdisciplinary problem based learning sessions. The problem based learning sessions were evaluated by surveying the participating students two months after the sessions took place. Limited hard data is collected in this pilot study. The project is motivated by, firstly, current trends in education and learning, and secondly, the role IT professionals play in shaping the future society. It is claimed that traditional teaching does not coincide with the demands of the IT professionals. PBL is proposed as an alternative where both knowledge and methods for acquiring the knowledge is considered. The paper reports on lessons learned and conclude that problem based learning is a viable approach to train IT professionals after considering some critical factors concerning introduction and implementation.

1. Introduction

The modern educational system was developed roughly a hundred years ago to teach the students the skills necessary and the facts applicable to survive in the industrial society; facts that would be true and skills that would be useful throughout their entire life. The factory was the model of choice; all students learn the same way and should learn the same things; all should be at the same place at the same time; and facts are transmitted to the students and later measured through instruments like written exams. But things have changed: "Schools today are structured more for the industrial age ... problem is, those factory jobs don't exist anymore" (Soloway 1993).

In the information society, preparing, or educating, information technology (IT) professionals is a difficult task. The information age changes people's lives. Some jobs are disappearing, others are emerging, while still others are being radically transformed by information technology. Not only will IT professionals live in a time of accelerating change, but even more important, they will certainly contribute to this changing society with their knowledge about information technology, and the use of the same.

Scanning the literature, it is easy to see that the current trends in pedagogy are very critical to traditional educational approaches in preparing students for the information society. For instance, students will be ill served if educational institutions provide them with products or outcomes of enquiry without learning how actually to pursue enquiry (Margretson 1991). But also, "Gaining automaticity in skill can free the mind for thoughtfulness" [...] "but isolated skills are not the sequential building blocks that lead to skilled problem solving and flexible complex thinking" (Hawkins 1993). Therefore, problem based learning (PBL) is suggested as a pedagogical approach to provide information technology professionals to be, not only with the knowledge, but with the necessary tools to acquire new knowledge in the future.

The paper is organized as follows: The first section discusses the relation between teaching and learning. Then the foundation of problem based learning is briefly explained, followed by an outline of PBL in practice. The next section describes the PBL related material used in the pilot project and the participating students. "Analyzing the Survey" is the

next section. Last, there is a discussion section with lessons learned, and some tentative conclusions.

2. Teaching or Learning?

Academia requires students to acquire facts, knowledge and wisdom. All in a holistic view which includes the preparation for participation in family, different communities, work and national structure. Additional goals for the learner could be personal growth, and an increased capacity for learning, critical thinking and creative problem solving. The goals of higher education are demanding to both students and teachers.

It is not difficult to find critique of contemporary educational practice. That includes the content covered in the courses (Dahlbom and Mathiassen 1993) as well as a more universal critique of the way it is taught (Pea 1993; Scardamalia and Bereiter 1993). In this paper, common educational practice is questioned as the appropriate way to prepare IT professionals.

The intention is this paper is not to further problematize the understanding of either teaching or learning. Characterizing conceptions of learning a framework involving two archetypes can be applied. First, open learning, which builds on constructivism and social interaction (Harasim, Hiltz et al. 1995). Second, closed teaching, which is rooted in an objectivist ideal of teaching and learning. In practice, these two can best be viewed as opposite ends of a continuum. In what we call closed teaching it is assumed that students have to have the knowledge required to approach a problem before they can start on the problem, learning-before-doing; whereas open learning the knowledge arises from work on the problem, learning-by-doing (Ross 1991; Pea 1993).

Closed teaching lays itself open to what Popper has disparaged as 'the bucket theory of the mind' (Margretson 1991). A theory that regards the mind of the learner as an empty bucket, which has to be filled with information before it can 'know' anything. A notion captured by Margretson who states that: "It echoes the misleading model that has plagued education for centuries, the Lockean model of the mind as a tabula rasa waiting for the teacher to write on it. This implies a conception of teaching as little, or nothing, other than the transmission of information from active teacher to passive students" (ibid p.49). If we teach the students what to learn, we stimulate the desire to pass examination. Practicing open

learning on the other hand, we teach the students how to learn. This way we stimulate their desire to inquire and to learn more, the knowledge will come automatically. Open discovery and guided discovery (Swanson, Case et al. 1991) are similar conceptions of the dichotomy.

Discussing closed teaching and open learning there is a risk that more superlatives are used in characterizing the latter, and verbs with a slightly more negative tone in the former. This is the case in this paper. However, this is a very simplified conception of the very complex process of learning. It is admitted that closed teaching has qualities useful to fulfill certain purposes in high quality education. I agree with White and Purdom (1996) in that: "Much of the conflict about what should be done in education begins to make sense if we can understand the different mind-sets that generate the different proposals." Open learning and closed teaching can be regarded as examples of mind-sets. The lists below summarize the two end points.

Open learning

- **Education is a flexible system with a learning environment designed to meet each student's abilities and needs.**
- **The building blocks of learning are semi-structured real world problems.**
- **Students are individuals with unique learning styles and interests.**
- **Students work cooperatively, gathering facts, and develop skills in decision making, problem solving, and information processing.**
- **The teachers provide activities and materials that require students to transfer and combine skills learned.**
- **Finding, evaluating, systematizing and interpreting information is the purpose of learning activities and necessary skills for the future.**
- **Teachers are facilitators who guide students in the knowledge. Students work in small clusters talking and planning together.**
- **The teachers play the devil's advocate by questioning, debating and challenging the students.**
- **The teachers help students in setting the personal goals, facilitate problem solving and critical thinking. But the students are responsible for their learning.**

- **Computing technology is used to enhance open interaction, reflection, and communication.**
- **Asynchronous activities are central. Reflection is necessary to relate newly acquired knowledge to previous.**

Closed teaching

- **Education is built as a rigid system with all students conforming to standard behavior expectations.**
- **Teachers are sources of all knowledge with all students quietly sitting in neat rows and all facing front.**
- **Students are uniform empty vessels to be filled with the same knowledge stuff.**
- **The teachers control the students by written exams where the students are to recall the newly acquired knowledge.**
- **The teachers ask questions and expect the students to provide an immediate and correct answer.**
- **To be time efficient the teacher scans available material, filters out the important. The students do not have to waste time searching for information.**
- **Students work in isolation from each other gathering facts and memorizing models with little concern for their application.**
- **The building-blocks of knowledge is structured facts, theory and models organized by the instructor.**
- **Teachers are experts responsible for organizing facts and information and transmission of the same to the students.**
- **All technological artifacts are used to make information transmission more effective.**
- **Activities mainly take place on-line and face-to-face.**

As with most polemics, there are elements of truth at both extremes, but most of reality lies in between. In other words, we are looking for the eclectic balance between teacher centered teaching and student centered learning. Let us look at problem based learning as an alternative to reach this balance.

3. Problem Based Learning is Not Teaching

Problem based learning is *not* another way of teaching. Learning is something students do, not something that is done to them. This way PBL is a fundamentally different approach to learning than traditional teaching. Problem based learning represents a significant challenge to orthodox beliefs about education and learning (Margretson 1991). Central in problem based learning is the students' development of independent life-long learning and an inquisitive relation to professional as well as other dimensions of their lives. Their own questions, formulations and conceptions of problems serve as the basis for learning. Another reason for using problem based learning is that "system developers need frameworks for thinking within which they can apply their knowledge to the challenges they face in their practice" (Dahlbom and Mathiassen 1993). Problem based learning can serve as the scaffolding for such a learning process. Scaffolding is an educational term that describes this guidance and support the teacher provides to the learner (Watson 1996).

As PBL encourages open-minded, reflective, critical and active learning it can be a threat to the teachers who prefer passive students and maximum control over what is to be learned. In line with this, it is also a threat to those who conceive education as a one-way process of information transmission. But, to those who believe in mutual learning and feel comfortable with unpredictable outcome of activities, PBL pays respect to both students and educators as individuals with knowledge, understanding, feelings and interests who come together in a shared learning process.

Problem based learning reflects the nature of knowledge, that is, knowledge is complex and changes as it is communicated among persons and communities. This is a threat to those who hold the conception of knowledge as information to be transferred. Also, it is a threat to those who restrict the notion of problem to small, atomic, single difficulties with a single optimal solution. For the students, ownership of the problem is crucial. That is, the problem must be identified and defined by the students. Otherwise, the students spend their time figuring out what the teacher wants.

Adapting to, and participating in, change and self-directed learning are composite competencies today. Problem based learning as pedagogy and methodology is expected to fulfill two distinct purposes (Engel 1991). First,

PBL is a method that will assist students in developing a set of competencies:

- **adapting to and participating in change,**
- **dealing with problems, making reasoned decisions in unfamiliar situations,**
- **reasoning critically and creatively,**
- **adopting a more universal or holistic approach,**
- **practicing empathy, appreciating the other person's point of view,**
- **collaborating productively in groups or teams,**
- **identification of own strengths and weaknesses, and undertaking appropriate remediation, e.g., thorough continuing, self-directed learning.**

Second, PBL is an approach of choice, because it is suitable for adult learning. Problem based learning is active learning through own questions and seeking the respective answers:

- **PBL puts learning in the context of real-life situations, learning for understanding, through appropriate opportunities to reflect on their education experiences, is emphasized rather than recalling of isolated facts,**
- **learning becomes progressively less straightforward and more complex, but also more challenging.**

3.1. Problems with PBL

Some problem based learning becomes mechanical in practice, destined merely to train students to solve problems and acquire the knowledge needed for the specific problem [Drinan, 1991 #903]. In these cases the opportunity for deeper, holistic and creative thought is lost through a prescribed path of exercise.

Students familiar with the traditional classroom are likely to be uncomfortable with the PBL format for some time. A big challenge for the teacher is to pursue students that they are looking for information and solutions to problems that may not have a single right answer. But some teachers seem to have a hard time to work with problems without definite and right answers. Many students demand to get the information what

they really have to do to get their grade. They will expect the teacher to prescribe a number of tasks, events, concepts, and a set number of pages followed by a written exam. Those students adept at traditional book learning may feel uncomfortable in problem based learning roles in which they have to conduct research, coordinate with peers, and generate unique products.

Problem based learning is not giving up all the responsibility to the students. This is a common misinterpretation. Enormous responsibility lies on the teacher's ability to establish a good environment for the learning process. Teachers new to problem based learning may be tempted to give students key variables, too much information, or problem simplification during the process. Depending on the students' ages, complexity generates relevance and interest, teachers' interactions should be at the metacognitive level and discussion about the content should be avoided. If not, it implies that there is a "correct answer" and this takes away the student ownership of the problem. Ownership of the problem is essential. If the students do not own the problem, they will spend their time figuring out what the teacher wants.

A signal teachers and students must pay attention to is the presence of the dreaded "second question." In traditional lectures teachers ask questions and a follow-up question to a student's reply usually sends the message that the answer was "incorrect." The students then spend time trying to figure out what the teacher wants. Regularly asking students to elaborate sends the message that the teacher wants to know what the student thinks and why. Awareness of students' opinions is an instructional point of departure that to some extent is a way of implementing personalized education. Teachers who operate without awareness of their students' points of view risk to lead students to dull and irrelevant experiences, and in worse cases, even failure.

4. Problem Based Learning in Practice

PBL in practice can take many forms but the focus is always on the student owned problem. In this project the core of problem based learning has been the 'base-group' where the students work on a case in self-organized groups, or teams, of six to eight members. Preceding the group work on the case a regular lecture was performed where central concepts to the case were introduced. Ideally, each base-group retires to a private seminar room. The problem is presented through a vignette. In this form of

PBL, a vignette can be anything between a single paragraph, some graphics, cartoons and a twenty-page case study. It can also be a brief "mini-lecture" where the problem is introduced.

Then, a teacher or other instructor facilitates the group process, but keeps a low profile not to interfere with the dynamics of the group. The work of the base-group is guided through the seven-step model outlined below. The model is divided in two phases and seven steps. Phase one consists of two to three hours of concentrated discussion and work in the base-group. The teacher facilitates this first phase. In the second phase the students organize their own work. Of course they have access to the facilitator for any questions that may surface during this phase.

Introduction:

- **Concepts central to the session are introduced and made clear through a lecture.**

Phase 1:

- **Step 1: Read through the distributed vignette. Make clear and explain concepts so everybody in the group understands the concepts used in the vignette.**
- **Step 2: Clearly define the problem or phenomenon the group wishes to work with.**
- **Step 3: Take stock of the ideas and opinions about the problem or phenomenon within the group. Divide the problem or phenomenon into sub-problems. Devote ten minutes of brainstorming for each problem found.**
- **Step 4: Systematize the brainstorming. Find relations, categorize and eliminate irrelevant sections of the brainstorming.**
- **Step 5: Frame questions to continue working with. Formulate concrete learning objectives.**

Phase 2:

- **Step 6: Search and gather information and facts. Work with the data to form knowledge in relation to the learning objectives. Work individually or in small groups.**

- **Step 7: Systematize the new knowledge. Validate the knowledge in relation to the problem. The knowledge should provide an understanding of the questions from step 5.**

5. The Vignettes

Four lectures in an undergraduate course in introduction to databases and systems development were modified according to PBL principles outlined above in the pilot project. The lectures covered four problems that are described below. The class was divided into groups of six to eight students at the start of each PBL lecture. The first phase of all the PBL sessions took place in lecture-halls, as no seminar rooms were available. The author facilitated up to six groups at the same time.

5.1. The Vignettes

All vignettes were developed by the author from components of real case studies, incidents or anecdotes, and aimed to fit the course as well as within the curriculum. Of course, a vignette is a simplification of an aspect of the real world. The vignettes used here might be considered naive, but the aim is to challenge and stimulate the students. The vignette is a starting point, nothing else. The four vignettes the students worked with are summarized below.

5.1.1. User participation

A vast body of literature covers systems development, project management, and group dynamics. However, this literature does not mirror the complex reality of professional practice. The objective of this first session is to increase the understanding of problems related to the relation between the users and the experts in a systems development context. The students are expected to understand the difference between user participation, participatory design, and expert design; and to discuss possible problems in systems development teams and how to deal with these problems. Below is short dialog between an IT expert and a user.

The new computer based surveillance system is installed at the industrial plant and the project is about to finish:
The security guard — "I will not use the new computer system. It is way too hard to use, and I am sure some manager is using the system to monitor us and our work. Nobody asked me about the need for any computer system. I am sure all of my colleagues agree on this."

The project manager — "We did ask you about your preferences for the new system: You did have time to read through the system specification before we started programming. I can't understand. What's your problem."

5.1.2. Method, methodology, or not?

A crucial condition for designing and implementing a high quality computer system is a well working project team. The team needs to explicitly coordinate different tasks and activities. A method or methodology is commonly used for this purpose. The objective of this session is that the student should understand the difference between method and methodology and discuss problems and situations that are likely to appear in the first project they will participate in.

A new computer system is to be developed at a large company. The project team consisting of eight people is gathered for the first meeting. Their experience of IT projects varies and none of them has participated in the development of a new system over the last three years. Kerstin from customer service is appointed project manager, and Gösta from the computer department as second in charge. Kent is the youngest in the team and a newly graduate from a four-year Informatics program. First on the agenda was how to organize the work.

Kerstin — "First of all we need to choose a method. This is a crucial decision for the eventual success of the project. Also, management requires us to document the work thoroughly."

Gösta — "Method? I have never needed a method before. I believe that we all are experienced, and do not need some red tape tampering our work. I have worked with computers for more than 20 years."

Kent — "This is my first project ever and I would like to follow a method. At the university, we did come across a number of methods. Maybe we could use one of those?"

Gösta — "Kent, listen to me. You have probably learned a lot of things at school. But this is reality."

Maria — "Why make such a big fuzz about it. Let us pick a method to satisfy management."

5.1.3. Local or central databases?

Storage of data can be distributed throughout an organization. The objective of this session is that the students should: understand the difference between locally and centrally stored data; discuss and understand advantages and disadvantages of each strategy; and discuss how to reach a proper balance between the strategies.

At a meeting, hospital management discusses IS/IT strategy. The matter under discussion is the new patient data system and whether data about patients should be stored locally at each clinic, or centrally at the computer department. A full day is devoted to this matter.

CIO of the hospital — "Obviously, data about patients must be stored in a central facility and managed by computing experts. This is necessary to guarantee security and integrity of the sensitive information. Information in the hands of the wrong people might be catastrophic. A central database is the only alternative and my department have the right knowledge and experience for this."

Senior physician of psychiatry — "From my opinion, information must be stored locally. To me, responsibility of the patient includes the responsibility for the information. And psychiatric information is of no interest to others than us. Why should the information be stored anywhere else than with us, it is ours."

Professor of social medicine — "I totally disagree. We use a lot of psychiatric data in our research. What you call your data is very valuable to us. That is true for all patient data within the whole hospital and I think I speak for many other departments."

5.1.4. Escalation situations

The fourth vignette was slightly different from the first three. In this PBL session, the students faced a case about a systems development project plagued with problems. The students are guided through three years of the project which experiences deeper and deeper problems. The question whether to continue or abandon the project is surfaced constantly, but the project is always continued. At the end of the case the students was asked to answer a few questions about the project. The questions concerned whether the project was in trouble and if the project should be abandoned. The students were asked to complete the questions individually. The facilitator then asked them to reach consensus on these questions.

The objective of this session is to introduce the students to a common phenomenon in many projects, and especially IT projects, namely escalation situations. These are situations where people have continued commitment to a course of action despite information suggesting that the course of action is failing (Keil 1995).

5.2. The Learners

To collect feedback from the participants I used a survey. Eighty-four students were enrolled in the ten week full time course part of the foundation year of a four-year program. The foundation year consists of four partly integrated courses. Most of the students had approximately six months of university education experience.

The four PBL oriented lectures were completely voluntary and involved no extra credits. No formal data of participants were recorded at the sessions. Approximately forty-five students attended each of the four sessions. Two months after the course, the students were approached via e-mail. The reason to wait was to give the students an opportunity to reflect on their experiences. Three open ended questions and a control question were asked in the mail. Forty-four students answered the survey. Collecting the answers required three e-mails one week apart. I did not change the tone of voice in the succeeding e-mail. The following text was included in all e-mails sent to all the students:

"During this spring, problem based learning (PBL) was used as an alternative learning model. To most of you this was a new experience. Two months have passed and I assume that you've had the time to reflect on whether PBL is a viable way of learning. I appreciate if you take a moment and answer the following questions:

- **What is your opinion about the PBL lectures?**
- **Comparing PBL with other lectures. What is the biggest difference?**
- **Which session [1-4 above] do you remember most? Why?**
- **How many PBL sessions did you attend?"**

6. Analyzing the Survey

The dangers and bias with this type of survey are well known. As the survey was conducted through e-mail, the students did not remain anonymous. About fifty per cent of the students responded to the survey. Despite limited support from hard data, my feeling is that this sample gives a fairly accurate view of the student group. The responses from the students were analyzed by categorizing keywords is their answers.

Norman and Spohrer (1996) have identified three dimensions to evaluate approaches to learning: engagement, effectiveness, and viability. According to Norman and Spohrer, engagement is the factor that can make more of a difference between success of failure than other factors. They continue to propose that one of the major themes of PBL is to use the problem as the primary motivation force. Students learn best when engrossed in the problem on hand and that students are engaged is rather easy to observe. The other two factors are more difficult to assess and certainly to measure. In the following section the students speak out about PBL. All quotes in this section, where no other source is given, are made by the students.

6.1. What is your opinion about the PBL lectures?

Seventy five percent of the students agreed that PBL is a viable approach in preparing them for their professional life. Twenty one percent had mixed feelings, and four percent did not believe that problem based learning is a feasible approach. Analyzing the responses to the question, five categories of answers appear.

First, it is obvious that PBL is new to most of the students. "You get to think yourself" was a spontaneous comment from several of them. Obviously the closed teaching paradigm is imprinted in many students. Moreover, "PBL felt like a completely new way of working at lectures" and "This was completely different from any other form of lecture I have been to," whereas only one student had previous experience as "this is the way we worked in high-school." Most of the students agree that "the sessions were very good, but also very frustrating in the beginning, before I understood the principles behind problem based learning." This is "certainly an element of future education, but we need more practice, and we need more facilitation."

Second, PBL is a viable way of learning according to the survey. "PBL raises questions rather than give you answers" and "This is learning for

life and not for the exam" are examples that speak for themselves. The relation to, and to some extent, applicability of problem based learning, in the real world were also a common observation, such as: "We worked with cases that are difficult to learn about by just reading about them, the cases gave us a better picture of real life. You had to (try to) experience the situation in order to understand it." The importance of making the objectives and the central concepts clear is also noticed: "These were the occasions when I learned most. Participating actively and putting theory into practice, this way the knowledge will last, but the preceding lectures could have been more focused on the cases than they were."

Third, problem based learning is demanding according to the students as the outcome of the group work is up to them: "PBL is what you want it to be" and "Some of the sessions were better and more interesting, of course it depends on yourself." That the students are aware of their responsibility for their own learning is apparent: "PBL requires that you are mature to a certain extent, as that you have the desire to learn" and "PBL makes you more responsible for your learning." One student wrote that "the knowledge might be harder to acquire, but I am sure it stays longer."

Fourth, it is difficult to re-learn if previous experience of education is mainly with closed teaching. Structuring a discussion concerning complex issues and problems was difficult as "same problems were constantly discussed in the groups." That common sense will get you to a certain point was not obvious to some: "As you do not have any real experience , you might not understand anything, maybe afterwards." It is also clear that some students did not understand the objectives with PBL. "Coming straight from high-school you don't have the experience to discuss these problems" shows that the principles of problem based learning were not fully understood. That is, common sense and group discussion will get the group to a certain point where the participants understand that they have to find information and knowledge from external resources, e.g., the literature.

Fifth, problem based learning is also problematic according to some of the respondents. "The sessions were a disappointment since I had expected a lot more technical and hands-on in this course." Others were less humble: "The first two classes were rubbish, the time would have been better invested in reading the text book." How the PBL sessions were related to the course and the curriculum was not clear to a handful of

students as they commented "More databases" and "How is this related to databases?" A few students were skeptic to work together with others: "I do not trust the group to perform a good job, so I rather work alone." There are also students who felt that the sessions involved too much control: "When we got the case and 'Objectives of the session' was written on the paper. I lost the interest and thought this was bogus. However, a change in current system is needed, so any approach that discard cramming is welcome, but this did not suit me."

Problem based learning is a viable way of learning according to most of the students. However, it is apparent that: "more introduction is needed as well as mandatory production of a report or similar" and an arena for discussion and feedback as many students "missed class discussion after the session." However, to be effective in their learning process, the students need to work with the problems according to the model before a general class discussion. This way the students have the opportunity to reflect on their new knowledge.

6.2. Comparing PBL with other lectures, what is the biggest difference?

The main difference recognized by the students were that in PBL you, as a student, have to be more active: "Compared to traditional lectures you are active." Or in other words: "Being physically present and mentally absent was difficult." To many students, problem based learning were "active sessions for those who wanted. If you are engaged, you get a lot back."

Most of the students found PBL sessions to engage, if not all, but more students than other activities. "More participation of the students, in other lectures are only a few students really participating." Other students found that: "In the group, everybody was engaged. Searching information and arguing for or against it, not only finding and delivering an answer or a definition without debate and reflection." The relation to traditional lectures was discussed: "You get only a little information, with regular lectures you get everything served." The satisfaction of discovery was obvious: "You feel like you are discovering the knowledge, if not yourself, but together with the other in the group" and then he adds "… which is actually what happens!"

PBL makes it possible for cases to come alive and connect with students' own experiences in life far more than would ever be possible in a traditional lecture. "It is closer to reality than working with the literature

and sitting through regular lectures" and "Here I can imagine real situations and understand the problems." The relation to course material was also pointed out: "It feels like it is closer to reality. Text books and traditional lectures cover how systems design and development should be performed, there is nothing about all the problems you will meet during the course of a real project."

PBL inspired to more independent work: "That I as a student can penetrate a problem and decide, individually or in the group, what the problem really is, and which aspect I would like to know more about. This way I got involved emotionally in some of the discussions, which helped me to understand." Others were insecure, but got "the opportunity to find my own standpoint." The closed teaching thinking is in attention again: "I can be creative, there are no definite answers." And that "brainstorming tended to include more aspects than if only the teacher suggest and present the standard aspects." Some students recognized the advantages, but seemed to prefer the traditional format: "The biggest difference was that I had to be more active during class, which is good. But I prefer to get more theories and facts presented by the teacher during class, then I can practice myself."

One interesting observation is that many students were somewhat uncomfortable and felt that: "It is difficult to know what you have learned" and "We were insecure when we decided whether to continue discussion or to move on." A viable way to find out if the student have learned anything is maybe as Scardamalia and Bereiter (1993) found out in an interview asking a 5th grader in the CSILE project (Computer Supported Intentional Learning Environments. http://csile.oise.on.ca). The student replies:

"I think I can tell if I've learned something when I'm able to form substantial theories that seem to fit in with the information I've already got; so it is not necessarily that I have everything, that I have all information, but that I'm able to piece things in that makes sense and then to form theories on the questions that would all fit together" (Scardamalia 1993 : p.38).

Most students find problem based learning as a viable alternative or complement to other lectures, or even stronger: "PBL is an excellent alternative. The current cramming is with no doubt completely out of date."

6.3. Which of the sessions do you remember most?

Almost all of the respondents could explicitly pin point one of the sessions. The two most mentioned are 'Local or central databases?' and 'Escalation situations.' As one student articulated: "the one about escalation. Some of the people in the group could not accept that a problem could be so complex that a final solution could not be presented within two minutes. This was interesting, but also frightening."

The first session, user participation, was the first time most of the students experienced PBL. One student wrote: "The first lecture, because this was something completely new. But I think I learned more in some of the other sessions."

6.4. How many sessions did you attend?

In the control question, seventy five percent of the students answering the survey attended three or four of the sessions. "All but one, I think?" is also a common answer from the students. This can be interpreted as if some students did not experience any difference between the regular lectures and the PBL lectures. And of course, "All, I usually attend everything, there might be something that I can learn."

6.5 Lessons Learned

Several important lessons have been learned from the four problem based learning enhanced lectures. As this was a new experience for most of the students, and certainly for me, some problems surfaced and some mistakes were made. This section describes the lessons learned.

First, a thorough introduction to problem based learning as a method and pedagogical philosophy is vital. The results of the survey as well as my own reflection show that the introduction was too brief to reach all the students. To make it clear, such introduction should not be aimed at *persuading* the students, as many students prefer other approaches to learning. My intention was not to "sell" PBL to the students, but to propose it as complement to other already existing educational activities.

Second, some form of incentive is necessary to motivate the students. Most students are rational and effective in their approach to studying. Students may find this type of sessions as valuable activities, but when not contributing to the final grade, they are likely to get low priority. The opportunity to interact with peers on problems is not motivating enough to them. The importance of incentive is discussed by for instance Hiltz (1997),

and others suggest that assessment must be an integral part of the PBL approach (Ma 1996). Incentives and embedded assessment will be a central design issue in the future work.

Third, coupled with the above is the need to expand the model with an eighth step. This step should involve the authoring of a report or a PM that should be reviewed by the instructor, another base-group, peer review, or an external reviewer. The intention to focus on the learning process in PBL can be enhanced by having to deliver a tangible product. This step is advocated by some PBL practitioners, but regarded as a misleading and even destructive step by others. From an orthodox problem based learning perspective, learning degenerates if a report is required.

Fourth, one of the greatest challenges for a PBL facilitator is to intervene in the group at just the right moment, not to disturb the group process: "The teacher was more passive and in the background (at least sometimes)." As I tried to facilitate up to six groups at the same time, this failed. "Getting guidance during the sessions was not easy since you had many groups at the same time." Those sessions when I only had two, and in one case only one group, came out very successful. Group size is also critical; six to eight students with a favor of eight is highly recommended to get fruitful group interaction. Facilitating base-groups is highly dependent on the engagement, both students and instructors: "I think you were more engaged in these lectures than in the others, which contributed to the better."

Fifth, location, that is the furnishing of the classroom. All the lectures were originally scheduled to rooms where all the furniture was fixed to the floor in face-forward and non-movable. This resulted in a very 'non-creative' setting. During these sessions, the base-groups had to form work-spaces where nobody were comfortable. Some groups that managed to find smaller class or seminar-rooms with white board or equivalent did have a very fruitful group process. But this created a logistical problem as I had to spend extensive time locating the groups.

Six, some of the students had expected a more technically focused course, and "was irritated that the course dealt that much with softer issues." Therefore the overall objective of the course and how "the database" fits into the course must be made very clear to avoid things such as articulated by one of the students. "Even if the softer issues are the most

interesting to me, I got disappointed since I had expected the course to deal with databases in a more specific way."

Finally, an holistic approach towards open learning, and preferably with problem based learning, is necessary to reach success. If only a few teachers during a program include open learning activities the students are likely to find them disturbing. "It is a problem that not more teachers use this approach." But I am also convinced that a gradual approach to introduce open learning in existing institutions are more successful than attempts to convert a whole program without first gaining the necessary mind-set and experience with problem based learning.

7. Conclusion

The pilot project helped to gain some important insights though some mistakes were made. The previous section demonstrated some critical factors in approaching problem based learning as an alternative. In a teacher centered classroom, a strict hierarchy of expertise is maintained. When closed teaching is replaced in favor of open learning, more specifically PBL, students experience a new relationship to each other. No longer is discussion a matter of student responses to teacher questions. The students become a team that is characterized by cooperation rather than competition. With PBL, the team of learners develops a healthy attitude to problems, knowledge and how to acquire this knowledge.

Teachers and administrators may resist collaborative methods such as PBL because of the new role for teachers, concerns about adequate coverage of the required curriculum, and difficulties in assessing the individual student. To many teachers, the role of a *"sage on the stage"* is very dominating. They will never take the role of the *"guide on the side."*

Problem based learning might be a desirable educational alternative, but relying solely on it is probably not advisable. Students do have different learning styles. During the ten week course both frustration and an interest in different aspects of learning among the students were articulated. I also found a growing critique of today's educational activities. Perhaps the most satisfying aspect of including PBL in the course was to see students transforming from rigid thinkers into more flexible thinkers who felt comfortable in less structured situations. Learning can become a joyful adventure that prepares students for effective participation in professional communities as well as for personal fulfillment. PBL is not a silver bullet, but adds dimensions to the learning process. The pilot project

has identified a number of areas for further research. Probably the most interesting is the relation between problem based learning and information technology. I see two areas where information technology will improve the problem based learning approach. First, the Internet as a technology for easy access to reviewed information in databases under the quality control of libraries and professional organizations. Second, the possibilities to use information technology to design vignettes. Finally, I would like to conclude that practicing open learning realized in PBL, I am comfortable in graduating professionals that will be shaping my future.

8. References

Dahlbom, B. and L. Mathiassen (1993). Computers in Context: The Philosophy and Practice of Systems Design, NCC, Blackwell.

Engel, C. E. (1991). Not Just a Method But a Way of Learning. The Challenge of Problem Based Learning. D. Boud and G. Feletti. London, Kogan Page Limited: 23-33.

Harasim, L., R. Hiltz, et al. (1995). Learning Networks - A Field Guide to Teaching and Learning Online, The MIT Press.

Hawkins, J. (1993). "Technology and the Organization of Schooling." Communications of the ACM 36 (5): 30-35.

Hiltz, S. R. (1997). "Impact of college-level courses via Asynchronous Learning Networks: Some Preliminary Results." Journal of Asynchronous Learning Networks 1 (2): 1-19.

Keil, M. (1995). "Pulling the Plug: Software Project Management and the Problem of Project Escalation." MIS Quarterly 19 (4).

Ma, J. (1996). "Group Decision Support System for Assessment of Problem-Based Learning." IEEE Transactions on Education 39 (3): 388-393.

Margretson, D. (1991). Why is Problem-based Learning a Challenge? The Challenge of Problem Based Learning. D. Boud and G. Feletti. London, Kogan Page Limited: 42-50.

Norman, D. A. and J. C. Spohrer (1996). "Learner-centered education." Communications of the ACM 39 (4): 24-27.

Pea, R. D. (1993). "The Collaborative Visualization Project." Comunications of the ACM 36 (5): 60-63.

Ross, B. (1991). Towards a Framework for Problem-based Curricula. The Challenge of Problem Based Learning. D. Boud and G. Feletti. London, Kogan Page Limited: 34-41.

Scardamalia, M. and C. Bereiter (1993). "Technologies for Knowledge-building Discourse." Communications of the ACM 36 (5): 37-41.

Soloway, E. (1993). "Technology in Education." Communications of the ACM 36 (5): 28-30.

Swanson, D. B., S. M. Case, et al. (1991). Strategies for Student Assessment. The Challenge of Problem Based Learning. D. Boud and G. Feletti. London, Kogan Page Limited: 260-273.

Watson, J. (1996). Reflection Through Interaction: The Classroom Experience of Pupils with Learning Difficulties. London, The Falmer Press.

White, J. A. and D. M. Purdom (1996). "Viewing Modern Instructional Technology Through Conceptions of Curriculum." Educational Technology Review (Autumn): 5-9.

Third Paper

Interactive Multimedia and Problem Based Learning:

Experiencing project failure

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Abstract

In this paper we discuss research on computer support for experiential learning and problem based learning (PBL). Experiential learning combined with interactive multimedia has received a great deal of attention in both educational practice and research. We suggest that the advancement of multimedia technology also provides an opportunity to extend problem based learning and combine it with experiential learning. We have focused on the very early phase of PBL, often called the 'vignette.' The vignette is used by the teacher to present a problematic situation that should serve as stimulus for a self-directed learning process. We have surveyed experienced PBL students and teachers with the purpose of finding ideas on how the vignette can be enriched or transformed by interactive multimedia. The analysis of the survey then served as input for the design of an interactive multimedia vignette prototype. The prototype was evaluated in two different settings: university and industry. Our conclusion is that the prototype works as a tool to integrate experiential learning and problem based learning. We found that the interactive multimedia added important dimensions to the first phase of the PBL model. We end the paper with a systematization of the results from the evaluation into a methodology, PIE, for integrating problem based learning, interactive multimedia and experiential learning. A more extensive evaluation of the prototype and the methodology will be reported at a later date.

1. Introduction and Background

A great deal of attention has been focused on interactive multimedia, especially within the educational domain. Many educational institutions have produced different types of educational interactive multimedia courseware to replace or enhance educational activities. In this paper we show how interactive multimedia can be used to combine experiential learning (EL) and problem based learning (PBL). Experiential learning is participative, interactive and applied. By experiential learning we refer to work in small groups, where what is learned is directly related to what happens in the group and how it happens. It is sometimes also referred to as learning-by-doing or learning-in-doing (Kolb, 1976). John Dewey recognized this already 1916 when he noted that schools continued to tell students what to learn despite research clearly showing that teaching by telling does not work, and that learning by doing does work. Examples of experiential learning are simulations where the students are (somewhat) in control of the process and different types of games such as role plays.

Problem based learning on the other hand is described by Boud and Feletti as: "…a way of constructing and teaching courses using problems as the stimulus and focus for student activity. It is not simply the addition of problem-solving activities to otherwise discipline centered curricula, but a way of conceiving of the curriculum which is centered around key problems in professional practice" (Boud & Feletti, 1991, p.14).

They continue: "…problem based courses start with problems rather than with the exposition of disciplinary knowledge. They [the problems] move students towards the acquisition of knowledge and skills through a staged sequence of problems presented in context, together with associated learning materials and support from teachers" [ibid.].

Using this understanding, it is clear that it is the problem that drives the process of learning, not the presentation of subject content or knowledge. Hence, the starting point of learning in PBL is a real world phenomenon or problem the learner wishes to learn more about. That is, a problem that is relevant from the perspective of the learner's future profession. The problem, or rather the problematic situation, is identified, designed and presented to the students, who then themselves define what the actual problem is. As most pedagogical approaches PBL has many strengths and offers opportunities. However, in this research, we would

like to focus on one issue we find to be problematic but also very central in PBL—namely introducing the problem.

The responsibility of the teacher is to present or introduce the phenomenon or problem in a stimulating way. In PBL, this is done through what we call a 'vignette.' A vignette is usually a document that can be anything between a single paragraph and a twenty-page case study. Graphics such as pictures and cartoons are used to enrich the vignettes, and recently, video clips are also used to add dimensions to the vignette. From the definition above of PBL, it is clear that the vignette is mainly understood as a starting point for self-directed learning. The experience of actually working with the vignette is not explicitly emphasized.

EL and PBL are alternative pedagogical models that are gaining popularity in all levels of the education system. Computing education such as software engineering, management information systems, computer information systems and informatics are no exceptions. The context for this research is computing education and training in a broader sense. In this research we use project failure as an example of a phenomenon that occurs frequently in different types of projects to exemplify our ideas. Using failures as a vehicle for learning is advocated by for instance Schank who claims that for learning to take place there has to be expectation failure (Schank, 1997). The learner has to experience something else than expected. He claims that real thinking does not start until the learner fails, and has to explain the failure. In other words, thinking and explaining catalyze learning. Outcome feedback is a similar and related conception—an action is taken and the learner observes the outcome.

IT project failures are well known to researchers and practitioners in both industry and academia. There is a large body of literature of case histories (Brooks, 1975; Oz, 1994; Sauer, 1993), empirical (Ewusi-Mensah & Prazasnyski, 1994; Ewusi-Mensah & Przasnyski, 1991; Lucas, 1975), efforts to systematize the empirical work (Flowers, 1997; Lyytinen & Hirschheim, 1987), and of how project failure should be approached in higher education (Nulden & Scheepers, 1998).

Project failure is strongly related to project management, a practical task educators often find difficult to teach realistically with traditional and conventional methods. Courses covering project management often simulate real world project like situations. The early project management simulations were built on very rational ideals, while current simulations

include more complex dimensions. Today, educators design cases and simulations where students are requested to perform in realistic situations and under business pressure. Common ways to enhance the realism is communication and interaction with simulated project staff, users and consultants. An other way is pin pointing typical project problems such as absenteeism, staff diverted to higher priorities, design problems, technical problems, changed requirements, personality conflicts, overstaffing and resignations. Educators try to make sure the students experience the situations as real as possible. Experiential learning such as scenarios and simulations are often realized using different types of technology. Section five in this paper discusses some examples of interactive multimedia for this purpose.

With problem based learning, interactive multimedia, experiential learning and computing education, more specifically project management and project failure, as a theoretical and contextual background we formulate the following three research questions to be further elaborated in this paper:

- **Can computing technologies enhance problem based learning? And more specifically addressed in this paper: How can interactive multimedia enrich the vignette?**
- **How can experiential learning and problem based learning be integrated in a methodology?**
- **Can interactive multimedia vignettes be used outside a formal education system to train and educate in project management related issues in corporate training programs?**

These questions were approached with a rather pragmatic methodological attitude. The aim of this paper is to explore the research questions and discuss design ideas with some limited empirical support. Therefore, this paper is mainly a conceptual paper. Methodological issues such as observation and content analysis are discussed in section six. The result of the implementation will be reported at a later date.

The remainder of the paper is organized in the following sections: First, learning and facilitating learning is discussed. Then in the section *Problem Based Learning in Practice* we outline our experience of working with PBL. In the next section, we give a brief overview of implementations of interactive multimedia in higher education. In the following section, we elaborate our ideas about PBL, experiential learning and interactive

multimedia vignettes. In the Evaluation section we describe how the ideas were evaluated using a low-tech prototype. A discussion of the evaluation is next and then we propose and outline the methodology we call PIE. In the last section, we draw conclusions, propose implications, highlight limitations and outline our future work.

2. Learning and Facilitating Learning

In this section we discuss problem based learning and experiential learning. We view the two from the learners' perspective as well as from the educators' perspective. PBL is a way of designing and conducting educational activities using problems as stimulus and focus for learner activity (Boud & Feletti, 1991). Similarly, in experiential learning the educator is providing stimulus to help students have a concrete experience.

The role of the teacher has surely become different and more complex. In our view, teaching is facilitation of learning and not a transfer of knowledge. Whereas much of the responsibility for the learning lies in the realm of the students, the responsibility of the teacher is to create conditions in which learning is possible (Laurillard, 1993). At undergraduate level, students are exploring already known knowledge, but they are breaking new knowledge at a personal level.

2.1. Problem Based Learning

Problem based learning is not another way of teaching as it builds on a fundamentally different understanding of learning than traditional teaching. Problem based learning represents a significant challenge to orthodox beliefs about education and learning (Margretson, 1991). We find PBL to be more of a mind set of the teacher and a philosophy about education then an educational methodology ready to be adapted by any teacher.

In PBL the students' own questions, experience, formulations and conceptions of problems serve as the basis for learning. Participating in change and self-directed learning are central competencies today. PBL is commonly claimed to be a method that will assist students in developing a set of competencies: adapting to and participating in change; dealing with problems, making reasoned decisions in unfamiliar situations; reasoning critically and creatively; adopting a more universal or holistic approach; practicing empathy, appreciating an other person's point of view.

In many ways, PBL is an implementation of the constructivistic model of learning. PBL is a change of understanding of learning from a transfer of information from teachers to students towards social interaction and individual constructing of knowledge. This model asserts that people construct knowledge by making sense in terms of what they already know. According to constructivism, people can only understand what they have constructed themselves (Leidner & Jarvenpaa, 1995). Learning is an active process when learners develop their own mental models. In our understanding of PBL the group is an important resource for the learning process and extending constructivism to include social interaction and collaboration among the learners we have a cooperative model learning or collaborativism (Slavin, 1990).

Constructivism and collaborativism are by default deep learning. Deep learning—compared to surface learning—is when learning goes beyond routine memorization of facts and instead towards a deeper understanding of the phenomenon under study (Ramsden, 1992). To take on deep learning the individual must be engaged (Norman & Spohrer, 1996). Therefore, to engage learners, PBL aims to challenge them enough to become involved in the problem and eventually, in the ideal situation, be true 'problem owners.' The ownership of the problem is one of the central principles of PBL as it is asserted that ownership is crucial for deep learning. To assist students in becoming problem owners they are challenged with an authentic task or problem that is relevant and presented in a context. This way the students experience the kind of situations they will be dealing with in professional life. The importance of making the experience as concrete as possible is emphasized by for instance Kolb (Kolb, 1976).

As PBL encourages open-minded, reflective, critical and active students it is a threat to teachers who search to maintain total control over the content to be learned and demand absorbing, passive students. Educators who conceive education as a one-way process of information transmission and restrict the notion of problem to small, atomic, single difficulties with a single optimal solution are uncomfortable with PBL. With PBL, the role of the teacher is changing from a provider of facts to the one who facilitates a learning environment and creates a sense of community.

As the starting point for learning in a PBL setting is the problem, challenging the students to become problem owners is sometimes difficult.

Some teachers manage to challenge students with very little. Others need some form of support. With this in mind, we have investigated the field of experiential learning to find support for design of vignettes that challenge students. From a PBL perspective the difficult task for the educators is to identify what type of experience the learner should have to become problem owners as discussed above.

2.2. Experiential Learning

Experiential learning is participative, interactive, and applied. It means contact with the environment and confrontation to processes that are uncertain. Experiential learning involves the whole person; learning takes place on the cognitive, affective and behavioral dimension (Gentry, 1990). The educator is responsible for providing the experiential stimulus. The quality of the stimulus will vary depending on the pedagogical approach applied. Gentry discusses different pedagogics and how they can be applied in experiential learning situations (Gentry, 1990).

In this research experiential learning refers to small group work, were what is learned is directly related to what happens in the group and how it happens. Various terms have been used to label the process of learning from experience. Dewey used learning by doing, and others have discussed this process in terms of experienced based learning, trial and error and applied experiential learning (Gentry, 1990), and that the best learning is *by doing* (Graf & Kellogg, 1990). Senge's reflection in action is another similar conception of learning (Senge, 1995). The Association for Business Simulation and Experiential Learning (ABSEL) Task Force defines experiential learning as:"*A business curriculum-related endeavor which is interactive (other than between teacher and pupil) and is characterized by variability and uncertainty.*"

In experiential learning, concrete experiences are subjected to individual and group reflections, sometimes referred to as process evaluation, as well as attempts to generalize in order to be able to experiment with new behavior. The learning at different levels can be conceptualized in two levels. On the one hand, individual orientation:

- **self-awareness by using personal inventories, reflections on one's own values, preferences and behavior in various work groups and feedback from others,**

- **recognition that people are different, and that such differences can be productive, and by using typologies such differences can be better understood, and**

- **empathy (feeling, insight into other individuals' values, ideals, orientations, etc., which can be different from one's own) through the same methods as above.**

On the other hand, group and organizational orientation:

- **group dynamics and processes by observation of actual behavior, such as group roles, development stages, cohesiveness, climate, conflict resolution, exercise of power, projections and other aspects of the emotional and cognitive tensions which are part of small-group life.**

Experiential learning has been practiced since the early 1950's. Examples of experiential learning are internships, live case, case studies, role-play, games and simulations. Simulations of different types are probably the most common and has long been a feasible way for educators to present complex matters such as visualization of mathematical, production and logistic processes.

Activities including experiential learning can also be damaging (Jones & McLean, 1970). The reason for the damaging effects, they explain, is that the instructor does not recognize the methodological conflict in using gaming and simulation. For the purpose of this research, we found a number of general characteristics of experiential learning activities that must be under the control of the educator or designer of the activity (Graf & Kellogg, 1990). First, *chained decisions*, where the result of one set of decisions influences the rest of the decision making process. Second, *debriefing*, which refers to the type of debriefing that is given after the activity has been finished. Third, *skill focus*, that refers to the type and range of skills being taught. Fourth, *computerized*, which refers to the rationale in the use of computers delivering the activity.

3. Problem Based Learning in Practice

In this section a framework for PBL in practice is outlined. The practical implementation of PBL does of course vary as this is only one possible model. Central to our model of PBL is the 'base-group' session where the students work in groups of seven to eight for one to two weeks. A course can contain one or many sessions, and in the extreme case consist of only base-group sessions. An educator facilitates the group process and assures that the group works according to the PBL model outlined below. The

critical issue is to facilitate but at the same time keep a low profile not to interfere with the group dynamics. The base-group work is guided by the eight-step model briefly outlined below. Before the group starts to work, a lecture, or equivalent, is held to set the borders of the session to start. This is done partly to make sure the students do not get lost in working with the vignette. This lecture and the delicate facilitation is to guarantee that the students cover, for the course, relevant material.

- ***Step 1*: Introduction to the vignette. The purpose of this step is to challenge the students by presenting the vignette with a content and a format so that they become problem owners.**
- ***Step 2*: Group discussion and identification of the problem or phenomenon covered in the vignette. If the problematic situation is presented in a challenging format, this step covers many aspects of the problem.**
- ***Step 3*: Brainstorming around the results from step 2.**
- ***Step 4*: Systematize the brainstorming in the previous step. Find relations, categorize and eliminate irrelevant sections of the brainstorming.**
- ***Step 5*: Formulate concrete learning objectives and state clear questions to work with.**
- ***Step 6*: Search and gather facts and information.**
- ***Step 7*: Systematize the new knowledge and validate the knowledge in relation to step 5.**
- ***Step 8*: Document and present the acquired knowledge in an appropriate way. Examples are reports, seminars, role plays and video to mention a few.**

The model is divided into two distinct phases. The first phase (steps 1 through 5) consists of three hours of concentrated discussion and work in the base-group supported by the facilitator. In the second phase (steps 6 through 8) students work on their own for, as in our case, one to two weeks.

Local or Central Databases

Storage of data can be distributed throughout an organization. The objective of this session is that the students should: understand the difference between locally and centrally stored data; discuss and understand advantages and disadvantages of each strategy; and discuss how to reach a proper balance between the strategies.

At a meeting, hospital management discusses IS/IT strategy. The matter under discussion is the new patient data system and whether data about patients should be stored locally at each clinic, or centrally at the computer department. A full day is devoted to this matter.

CIO of the hospital — "Obviously, data about patients must be stored in a central facility and managed by computing experts. This is necessary to guarantee security and integrity of the sensitive information. Information in the hands of the wrong people would be catastrophic. A central database is the only alternative and my department have the right knowledge and experience for this."

Senior physician of psychiatry — "From my opinion, information must be stored locally. To me, responsibility of the patient includes the responsibility for the information. And psychiatric information is of no interest to others than us. Why should the information be stored anywhere else than with us, it is ours."

Professor of social medicine — "I disagree. We use a lot of psychiatric data in our research. What you call your data is very valuable to us. That is true for all patient data within the whole hospital and I think I speak for many other clinics at this hospital."

Box 1. Example of paper based vignette

Above is an example of a paper-based vignette used successfully in an *introduction to database* course (Box 1). Note that this vignette is considered as very structured in the eyes of the more orthodox and purist PBL practitioner. The style of problem can be viewed as falling along a continuum, with students constructing the problems themselves at one end, and the teacher being fully responsible for the construction at the other end.

While it is very easy for educators to become enthusiastic about PBL as an alternative model, there are of course potential drawbacks. Some PBL becomes mechanical in practice, applied to train students in problem solving and acquire the knowledge for only this. It is also problematic that students many times rush into problem solving before the problem is really understood. In these cases, the potential for deeper, holistic, creative reflection and learning is lost through the predefined problem solving process.

4. Multimedia

Innovations in technology, such as multimedia, hypertext, video, the Internet and virtual reality, are now making impact on teaching and learning. The computer has made experiential learning a realistic option for many educators. In this section we make a brief review of some implementations of interactive multimedia (IMM) in different educational settings. The section is by no means covering the field of IMM in educational activities, but gives an overview with a few examples.

The design of interactive multimedia has undergone a revolution in the last ten years. Trivial HyperCard stacks and behaviorally oriented drill and practice applications common in the 80's have given way to richer interactive applications where the learner is relatively free to explore at her own pace. Recently, we find there is a shift from IMM supporting the individual learner to IMM supporting a group of learners. For instance, many application are designed to facilitate interaction between a dyad of learners working with the same PC.

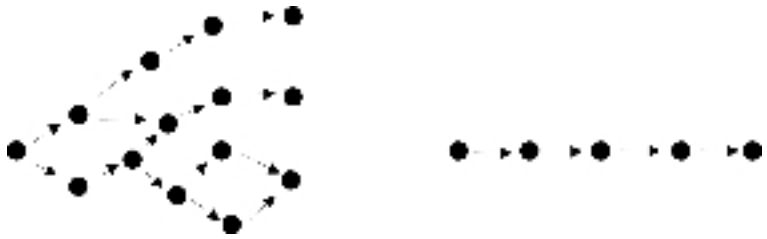

Figure 1. Graph of case based simulation and of interactive case

As shown above, the use of hypertext permits links among pieces of information such as text, sound and graphics, that permit the user to "explore ideas and pursue thought in a free and 'non-linear' fashion" (Bieber & Kimbrough, 1992). Kendall et. al. compare a hypertext based (IMM) computer systems analysis case with a conventional case and role playing (Kendall, Kendall, Baskerville, & Barnes, 1996). They found that use of hypertext allows students to navigate through the organization, interviewing and examining documents in the order they prefer rather than in the predescribed linear fashion. Their conclusion is that hypertext was an important departure from the traditional activities conducted. The interactivity and non linearity of hypertext means that the students learn

computer systems analysis and design by exploring an organization, rather than reading a case study of one.

In a medical education and training context, the Cardiac Tutor places students in situations where they solve problems while the system reasons about the problem being solved and about how to best respond to the students' idiosyncratic actions (Park Wolf, 1996). The Cardiac Tutor is a knowledge based simulation for teaching about cardiac resuscitation. The simulation was coded using extensive expert inputs. The goal for the simulation is very clear: save the patient by selecting the proper procedures.

Boston chicken is another example, a little less prestigious than the cardiac example, where trainees practice ringing up orders on a simulated cash register in order to become faster and more accurate, helped by an online tutor (Schank, 1997).

In a construction context (Ahmed, Thorpe, & McCaffer, 1997) discuss different simulations. Baumark I and II simulate different stages in the construction industry. They demonstrate different types and sizes of contracts that might be undertaken by companies. The simulation puts the *players* in decision making situations and forces them to study their actions and reflect over the consequences. Similarly, Constructo—a construction project oriented game which gives students the opportunity to develop their own problem understanding and solving model. This by confronting them with simulated tasks and placing them in the position of being in charge of a construction project facing similar difficulties as real world managers.

In a systems development education context, Farrimond et. al. are applying current multimedia techniques to transform current paper based case studies into interactive multimedia simulations (Farrimond, 1997). They have developed a mouse driven virtual world. The goal of the interactive case study is not to lead or guide the students towards a specific goal but to provide a context in which to explore the 'real' world. The world in the simulation is a set of interconnected rooms which are populated by people, documents and other objects. The students construct own meaning by interacting with the material rather than being taught something explicitly. A fundamental principle in their work was to make everything as generic as possible through the use of a case study language (CSL).

In the examples above there are many different ideas about the desired educational outcome. Much of the multimedia training is no better than

the old—it just looks sexier. We can also see a shift from CD-ROM towards the 'web', as a dominating technology, but also a shift from multimedia for individual learners towards multimedia application for teams or groups of learners. This shift was described in a previous section of the paper in that constructivism is extended with the social dimension—collaborativism.

Many of the simulations outlined above are quite similar to what we suggest in this paper. They are all informed by experiential learning in the way they are designed. However, traditional scenario based simulations often provide only a few paths through a situation and no ability to adapt the presentation to perceived user needs or individual knowledge (Park Wolf, 1996). We also find that none of the simulations we have studied is explicitly building on the model of problem based learning. By this we mean that we can not find that they serve as a starting point for further work and learning. In the following section we elaborate these ideas further.

5. Design and Ideas

In this section we outline our ideas on how to combine experiential learning and PBL, and more specifically, the first step of the PBL process, that is, the vignette and how it can be more challenging. As stated before, advancements of multimedia technology provide us with an opportunity to enhance the design and presentation of vignettes. We have shown examples of the possibilities, and we have claimed that the examples do not explicitly build on ideas related to PBL.

Armed with this knowledge we continued by approaching an additional source of information. We surveyed twenty master level students, ten men and ten women, average age of 28 and all with at least six months experience of PBL and three experienced facilitators with two open ended questions through e-mail:

- **In your opinion, what makes a good vignette good, and what makes one poor?**
- **How would you describe the relation between the basic group, their work, and the vignette?**

As students and facilitators responded via e-mail they did not remain anonymous. However, we did not find this to be a problem in this type of survey. Content analysis was applied as methodological approach. That is the process of identifying, coding and categorizing the primary patterns in the data (Patton, 1990). The survey was analyzed by coding of keywords in

their responses. The keywords were then categorized in three main groups. From the two questions and through induction, three issues came out clearly. The quotes are taken from the e-mail responses.

- **First, several students pin-pointed what we call the soul of the vignette, "I think that it is important that the vignette shows that the author has put his heart in it, not just made 'another vignette'."**
- **Second, real world relevant cases, that is, material from what is happening in the world at the moment: "The vignette should include topics currently discussed in media."**
- **Third, variation and layout, especially in a longer module with a number of vignettes they have to be designed in various formats, and they should be "enhanced with something that exceededs the language."**

Some students also stated that: "*we miss the unexpected in the vignettes*" and "*we have not experienced any really touching vignettes.*" In addition to this, we find our own experience of facilitating PBL sessions to be consistent with these conceptions. Our major observation is that a great number of vignettes seem to have very low quality when it comes to stimulating and challenging the students. Supported by the literature, the result of the survey, and our own experience as facilitators we started to elaborate our ideas about multimedia vignettes. Figure 2 below summarizes the conceptual ideas in the research.

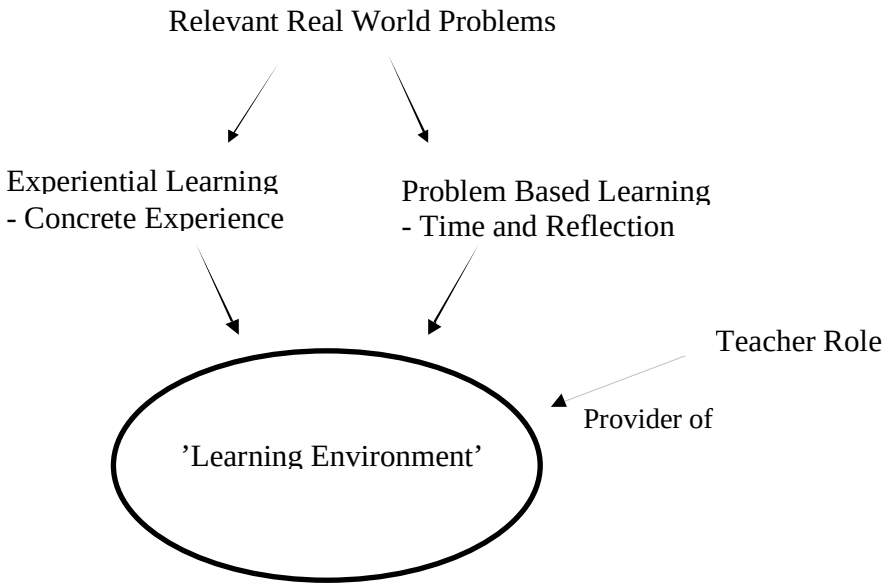

Figure 2. Design Framework

Basically, our idea is the design and development of a vignette about IT project failure as discussed in the introduction. The purpose of such a vignette is to direct the attention of the base-group to the complexity of IT project management. The idea is to have the base-group acting as project members. They will navigate through a project over time and make decisions about the project. Figure 3 below is an outline of a whole vignette.

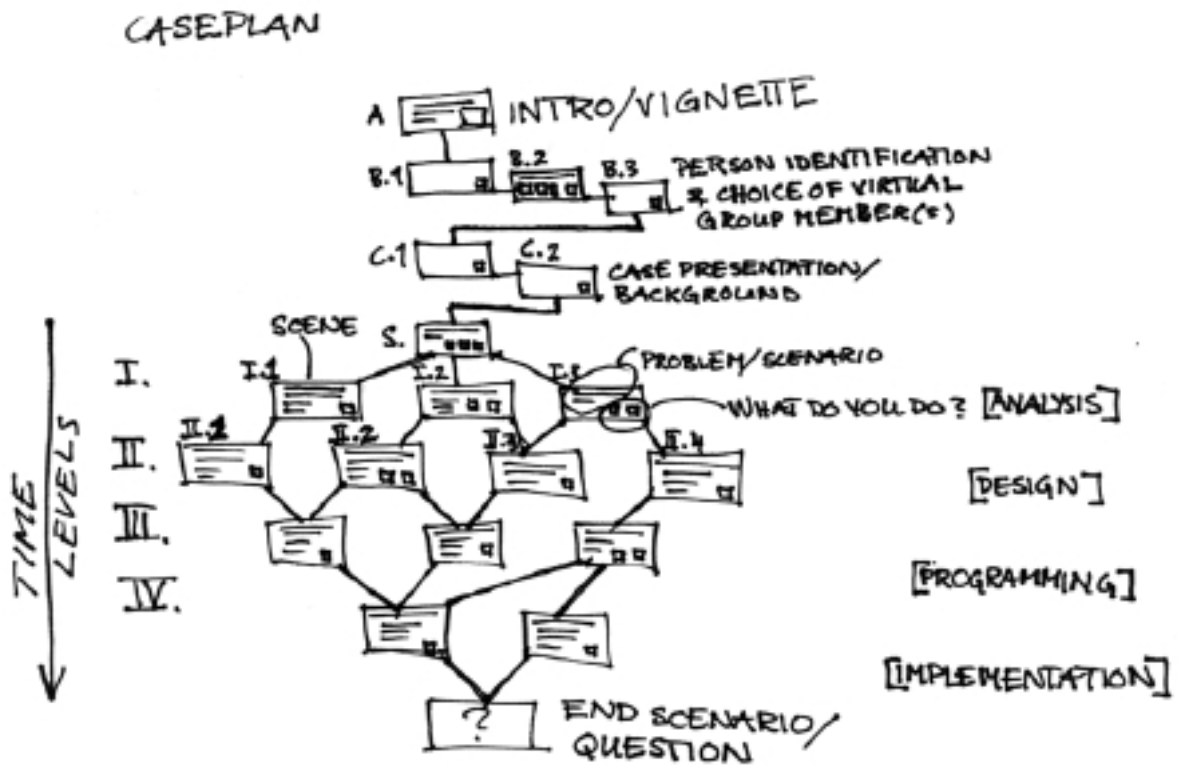

Figure 3. Outline of the whole vignette

To generalize the ideas, an important aspect of this research is to develop and establish a terminology for designing cases as described in this paper. The *scene* serves as building blocks for the vignette. New information about the project is presented in each scene and the group is required to make decisions about things such as technology, personnel and dates. Each scene in the vignette consists of a series of WWW pages with one or a number of objects embedded. Examples are graphics, sound, movies or database interfaces. The purpose of the scene is to present information to the base-group and in some of the scenes the group are then required to make a decision. Figure 4 below is an example of a scene where the base-group has to make a decision about choosing an additional 'virtual' project member.

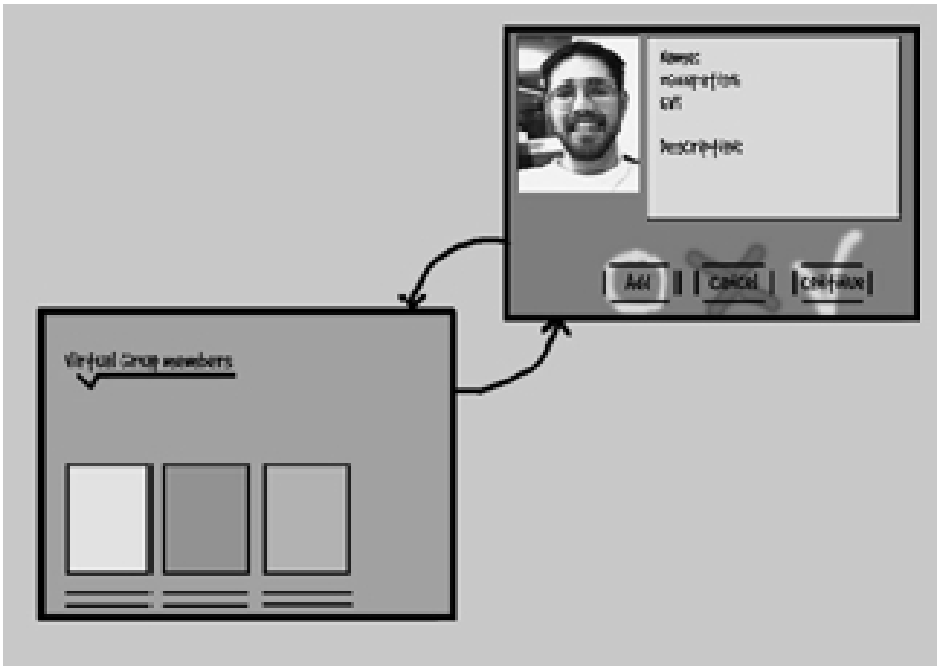

Figure 4. New virtual project member scene

The students get some background information to make the decision. In this scene, a simulated e-mail with the news that the most experienced programmer has suddenly left the organization and the project manager i.e., the base-group, has to hire a new programmer. In this example, they have three potential candidates, as shown in figure two. Information about each of the prospects is presented, such as CV, personal web page etc. Each person has both good and less desired characteristics, which makes the choice a trade-off for the group. No matter which person is hired, there will be consequences later in the scenario. Our intention is to make the students, not only read about the problem, but actively be part in the creation of it. That is, they experience the sense of time and how they have been part of the project during this time. Decisions made are actually made by the base-group and they have thereby invested themselves in the decisions.

In the scenario, time passes in the project and the group faces additional information, and has to make other decisions. Finally, as figure 3 about the whole case shows, the group will end up in the single last scene of the vignette. This is how the educator responsible for the vignette makes sure the students meet the learning objectives of the PBL session. Let us give an example of end scene. After the group has worked with the vignette for one hour and been confronted with various project problems, they have

been making a number of decisions about database managers, upgrading of software, hiring and firing of people etc. They are becoming more and more aware of that the project is probably about to fail. The last scene is from the board-room were the president of the company and the CIO question your (the base-group's) ability to manage the project.

6. Evaluation

Note that the evaluation is about a concept, not a functional prototype, nor any aspect of learning. In the evaluation phase we decided to include people from the industry. One of the reasons for involving industry, as stated in the introduction, was to determine if the interactive multimedia vignette could be used in a training situation with professionals. A second reason was to guarantee the relevance of the problematic situation to be described in the vignette. We suggest that many of the PBL ideas are easily transferred to other adult learning situations outside the formal education system, such as corporate training programs. Supporting employees in acquiring critical skills and knowledge quickly and effectively has become a organizational key objective, not just a training goal. As early as 1979, Warren made the strong statement that: "Training is no longer, like the house organ, nice to have if you can afford it. It is becoming a basic tool for increasing the effectiveness of the organization. […] The organization's problem becomes not whether to train but how" (Warren, 1979).

Two groups, one at the Business School of a Swedish University, and one at a large manufacturing industry in Sweden were selected to participate in the evaluation. Involving the industry introduced some additional constrains on the vignette. Our initial ideas with a vignette covering a whole project and a large number of problematic situations that are common in projects were reformulated. The industrial partner found the ideas interesting but wanted us to limit the problematic situations in the vignette to only a few. They suggested the vignette presented in the prototype to mainly deal with the problem of people coming and going in projects. The issue they were interested in was how to maintain an efficient group even if people come and go due to different reasons. For our purposes, this request did not require any major changes to the ideas. The prototype scenario was designed accommodating their requests.

6.1. The Interactive Case Prototype

Below is a short description of the scenario used in the evaluation. The prototype interactive case consisted of a sequence of scenes implemented in Microsoft Power Point (PP). The scenario contained a number of scenes setting the stage and providing the group with the background information about the problematic situation. This information was presented in smaller blocks of text on several PP slides. Figure 5 and 6 below are examples of scenes. The purpose of this was, as discussed above, to allow the group to reflect and discuss issues raised in the scenario while it was presented. After the group had received this information, explicit scenes where the learners (students and the industry group) were required to make decisions were presented. From a methodological perspective the evaluation was conducted through observation. Notes taken during the evaluation with the two groups are summarized below.

Figure 5. Scene from the interactive case

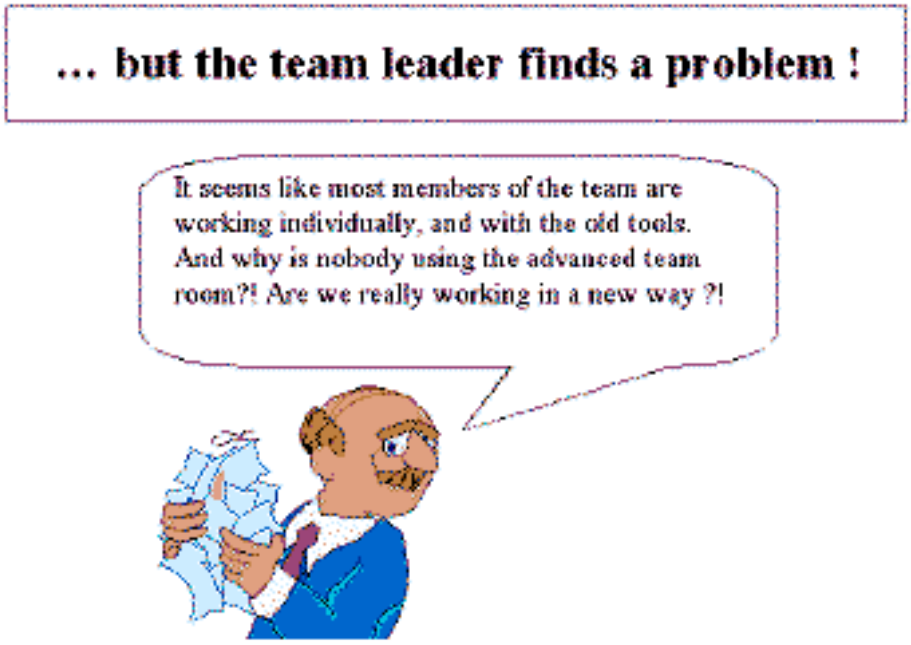

Figure 6. Scene from the interactive case

We decided to evaluate the prototype with the student group first. The reason for this is that we consider the student group to be fairly experienced with the PBL methodology and that the input we will get for them is valuable to prepare ourselves for the second group. This implicates that we could consider changes to the prototype before the second part of the evaluation. We also found approaching the students first would minimize the possible errors we otherwise would bother the professionals with.

6.2. Observing the Student Group

The student group participating in the evaluation consisted of a subset of the group surveyed about their opinions about PBL. Because of their experience with PBL, we found the group to be a very valuable source for evaluating the prototype. The whole class (21 students) of an MBA program were asked if they were interested in participating in a short experiment on computer supported vignette. Seven students were then chosen to participate in the evaluation.

The setting for the evaluation was a conference room with a table, a portable computer, a projector and a large screen to project on. The students were given a short description of our analysis of the survey, our ideas in general and the purpose of the vignette they were about to work

with. As all students were experienced with PBL this introduction was fairly short. Three persons observed the group and made notes. One of the observers acted as facilitator, but his role was very limited as the group was used to this form of work.

The person closest to the computer grabbed the mouse and started the scenario. The group worked quietly with the first eight scenes containing the background information. They nodded their heads when they were ready and waited for the next scene. No discussion or comments were made. The only sound came from the projector. However, when the first interactive scene appeared the discussion started. The discussion followed a pattern we had expected, but they also raised issues concerning the actual ideas about the prototype. The group constantly made connections to their own experience of PBL. As the whole group was from the same class they had a large shared background of experience for the discussion. This was the case for the rest of the evaluation session. Short comments made during the information scenes and more extensive discussions in the interactive or decision scenes. The group worked and discussed in an efficient and goal directed way. It was obvious that their experience of PBL helped them in structuring the group work in this phase of the PBL model. The discussion was raising issues concerning PBL as an approach and not less about the actual content in the scenario. Many ideas and aspects surfaced. We found this to be a very valuable input for the further design of the interactive case. The scenario in the vignette worked as recapitulation and evaluation of their own work during the passed year in PBL groups.

All members of the group found the prototype and the scenario to be of value. According to them it was easy to understand, although some found it to be too much text in some of the scenes. None of the students found the design to be too simple. A richer multimedia form with more embedded objects would not automatically raise the quality of the vignette, probably the opposite. However, the interaction was found limited due to the interactive case implementation with sequential scenes. Observing the students, it was very interesting to see how they altered their discussion from the actual problem presented in the scenario, to a discussion about their own relation to PBL.

That the scenario ended with a fairly concrete task for the group to work on was not a problem, this despite the fact that this is a conflict with the PBL methodology as discussed above. The group members themselves

should define the problem to work on, not be given a problem. Summing up the students' comments during the evaluation session they found that this type of scenario should work as a good way to introduce and engage students to work with different problematic situations. They emphasized that this was certainly a promising alternative to the traditional paper based vignettes they had worked with so far. Again, the group started a discussion about the uniform and very limited challenge offered by the vignettes they had experienced during the past year.

6.3. Observing the Industry Group

The evaluation at the industry was performed with professionals who work exclusively in projects and are organized in teams. The observation was conducted by a graduate student supervised by one of the authors. Of course the situation for the professional team was different from the situation of the students. However, we find the similarities more interesting to discuss in the light of this research.

The setting for the second evaluation was a team room at the industrial plant. It was not a room in the normal sense, instead it was a section of a larger room. The team room contained a large conference table, some smaller tables and a table with a computer and large screen where the evaluation was conducted. The group of people who initially agreed on participating was unfortunately not complete. Only four people from different teams were able to participate. The facilitator for the group belonged to a different department of the company. She received some instructions in advance about the role and purpose of the team leading role she was about to enter.

The team received a more extensive introduction to the task than the student group. The basics of PBL were explained as a background. They started out quietly much like the first group. They hummed after they had read through the text in the information scenes and the person with the mouse clicked on to the next. The work was methodological and gave the impression of being very efficient. When they reached the first interactive scene about whether work practice really had changed the group started a quiet discussion. The discussion escalated after a little while and they penetrated the alternatives, and agreed on one alternative. The facilitator was successful in trying to get everyone's opinions. Most comments were in the form of agreeing on what already was said and there were few real efforts in surfacing new aspects at this stage. The group felt a bit more at

ease and started to use the supplied drawing and writing material to articulate and explain their standpoints. At the next interaction scene there were further discussions. One person said "this is the way it is," and the others agreed. The team leader worked to get the group to reach consensus on the decisions to be made in this scene. Several team members worked through the text a number of times. Everybody seemed to wait for the others to make the first move.

When the group reached the actual task about suggesting an introduction program for new project members an extensive discussion was taking place. The roles of the different people in the group were that one person was actively brainstorming while one was actively concretizing the brainstorming. The other two had more drawn back roles and they added marginally to the ongoing discussion. Working with the task the voices were low, however when the discussion moved from a generic one to a discussion concerning their own work situation the discussion became tense. They question their own situation. The discussion went in circles — A depends on B that depends on A — for a long period. Suggestions on how to solve the problems are articulated, but many suggestions are not discussed at any length. The suggestions were different but also very conventional and rational. The team leader was trying to lead the group towards consensus. She was focusing on the most open person in the group by addressing questions directly to him. The others agreed to what this person said. For a moment they looked back at the eight-step PBL model provided, but the model was obviously confusing for the group. They finished their work and presented a draft of an introduction program for new project team members.

An interesting observation is that the scenario actually worked as a catalyst for the team to talk about their own situation in the company. They also raised issues that in no way were connected to the scenario. As with the student group, the team was stimulated to put their situation in a larger context, and viewed the work in the perspective of this larger context. We felt that they raised several issues of great value for their unit, and maybe for the whole company.

The team had no problem in moving through the interactive case. They recognized the issues raised in the scenario. Smiles and laughter were frequent as they moved through the scenario. One of the participants found "*the interactive parts to be good—you become engaged and 'wake'*

***up.*" The group agreed that the format was good in that they were introduced to a problematic situation in a stimulating way, and the team was presented with a task to complete. They found that the embedding of the instruction in the scenario was helpful. "*When you do it yourself you engage in a learning process that is much more efficient than a traditional one.*" Similarly to the student group, they did not think that additional multimedia would automatically add anything to this type of scenario. Sounds, animations etc., could actually be disturbing if they are not found motivated. The team suggested a more explicit structure of the scenario and a more explicit assignment related to their current problems. They also suggested that this could be solved with a hypertext based structure instead of the sequence they were presented with in the evaluation.**

7. Discussion

The evaluation raised several issues we discuss more in detail in this section. Summing up the evaluation we found that the student group approached the scenario from mainly a PBL perspective. The interactive scenario stimulated them to work as with a PBL vignette. The industrial team worked with the scenario from their current situation and experience. The interactive scenario was in many ways a catalyst for them to reflect on their own actual work situation.

Observing the students work with the scenario it is obvious that this type of alternative vignette add to the process of PBL in a formal educational setting. The prototype was easy to use as the interactive scenario consisted of a sequence of PowerPoint slides. The student group focused on the intended issues before they reached the end of the scenario. The group stopped at the interaction scenes and discussed the situation, they reflected and analyzed the situation to understand and problematize. We did not get the feeling that they were rushing to move on in the scenario. On the other hand, they did not spend *too much* time either. A very important observation is that they clearly spent more high quality time with this vignette than when working with the traditional paper based one. However, this was only one observation and there are certainly a need for more extensive, systematic and in-depth observation.

The industry team found a lack of structure in the scenario. This is a very delicate problem to approach. On the one hand, the scenario must not be too superficial and put words in the participants mouths. The scenario should guide the group, but not control them. On the other hand, and from

the company's side, the aim or the expected outcome must be very clear. PBL was seen as a somewhat 'unstructured' approach. As the group, according to PBL, defines their own problem. However, here the problem and the task for them to work with was provided in the scenario and perceived as satisfactory.

In this research we did not attempt to measure some dimension of learning, as this is not within the scope of this research. However, we do use our own judgement of how engaged the students are. Our full conviction is that when students are engaged and work hard by their own interest, they are actually engaging in deep learning. Comparing this to case teaching we find many similarities, but also many differences. One is that the vignette is more of a starting point than a case. That is, in case teaching the case discussion is the main learning activity, which is consistent with experiential learning. Whereas the vignette in PBL is aimed at mainly starting the process. Therefore, in this research, we have combined the ideas of 'actual learning' and starting point.

7.1. Proposing a Framework and a Methodology

With the discussion above as a point of departure, we propose a methodology, PIE, which is outlined below (Figure 7). Problem based learning, Interactive multimedia and Experiential learning (PIE) is a three phase methodology for structuring educational activities in modules, using case based simulations.

Phase one.	**Experience. The group experience the interactive case facilitated by an instructor. The instructor ensures that the group reach the end of the scenario and leave the session with the problem on their mind. Duration two hours.**
Phase two.	**Reflection. Duration one week**
Phase three.	**Feedback and discussion. The group meet together with the instructor and discuss the problem presented in the interactive case. Duration two hours.**

Figure 7. Framework and Methodology for PIE

8. Conclusion

In this section we draw conclusions, propose implications, highlight limitations and outline our future work. This paper has discussed how experiential learning (EL) and problem based learning (PBL) can be integrated by the use of interactive multimedia (IMM). We have designed an interactive case prototype about project management. The prototype was evaluated in two different settings. The three research questions below guided the research and serve to summarize the findings.

- **Can computing technologies enhance problem based learning? And more specifically addressed in this paper: How can interactive multimedia enrich the vignette?**

Using information technology to search information on the 'net' is a natural activity in PBL today. Technology for student presentations, for instance PowerPoint, is also frequently used in a PBL context. The vignette has not received the same attention however. Our limited evaluation suggests that interactive multimedia enhanced vignettes provide dimensions to PBL. A main advantage we found in our evaluation was how interactivity of the vignette slows down the process. In other words, we can help (force) the students to spend longer time at the problem understanding and problem definition phase.

- **How can experiential learning and problem based learning be integrated in a methodology?**

We have proposed PIE as a methodological approach for integrating Problem based learning, Interactive multimedia and Experiential learning.

- **Can interactive multimedia vignettes be used outside a formal education system to train and educate in project management related issues in corporate training programs?**

We claim that PIE is an approach that is useful in organized corporate training about project management. The three phase approach provides both experience and time for reflection.

The main limitations of this research, as we see it, are two. First, the very simple prototype designed to implement our idea about interactive multimedia vignettes. Second, the limited evaluation conducted. However, as our aim with this paper is to discuss the problem of challenging learners in a PBL setting, and suggest how these problems can be handled, we do not find these limitations to be problematic for our purposes in this paper.

Whereas the findings so far are tentative, we argue that the survey showed us some important things about the design of vignettes, both traditional and multimedia. For the continued work, we will involve more professionals to ensure reliability of the content in the next phase which is to fully implement the *failing project vignette,* followed by an evaluation of the usefulness of it. We are currently transforming the ideas to a web-based interactive scenario. Further, our intention is to explore the possibility to develop a generic framework or software tool for the design of multimedia vignettes.

The questions also initiated informal discussions among the students. This was the case with the evaluation too. We believe this type of intervention in an ongoing educational program, in this case a program where PBL was the main form of activity, invites to reflection and discussion among the people participating, learners as well as educators. This will result in a deeper understanding of the educational process and how it can be improved.

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9. References

Ahmed, V., Thorpe, A., & McCaffer, R. (1997). MERIT 2: A construction management simulation. In P. Saunders & B. Cox (Eds.), *The International Simulation and Gaming Yearbook Volume 5 - Research into Simulations in Education* (pp. 28-37). London: Kogan Page Limited.

Bieber, M. P., & Kimbrough, S. O. (1992). On Generalizing the Concept of Hypertext. *MIS Quarterly, 16*(1), 77-93.

Boud, D., & Feletti, G. (Eds.). (1991). *The Challenge of Problem Based Learning*. London: Kogan Page Limited.

Brooks, F. P. (1975). *The mythical man-month - Essays on Software Engineering*: Addison-Wesley publishing Company.

Ewusi-Mensah, K., & Prazasnyski, Z. H. (1994). Factors contributing to the abandonment of information systems development projects. *Journal of Information Technology, 9,* 185-201.

Ewusi-Mensah, K., & Przasnyski, Z. H. (1991). On Information Systems Project Abandonment: An Exploratory Study of Organizational Practice. *MIS Quarterly, 15*(1), 67-88.

Farrimond, B. (1997). Using Multimedia to Present Case Studies for Systems Analysis. In P. Saunders & B. Cox (Eds.), *The International Simulation and Gaming Yearbook Volume 5 - Research into Simulations in Education* (pp. 135-143). London: Kogan Page Limited.

Flowers, S. (1997). Information Systems Failure: Identifying the Critical Failure Factors. *Failure & Lessons Learned in Information Technology Management, 1*(1), 19-29.

Gentry, J. W. (1990). What is Experiential Learning? In J. W. Gentry (Ed.), *Guide to Business Gaming and Experiential Learning* : Association for Business Simulation and Experiential Learning (ABSEL).

Jones, M. M., & McLean, E. R. (1970). Management Problems in Large-Scale Software Development Projects. *Industrial Management Review, 11*(3), 1-15.

Kendall, J. E., Kendall, K. E., Baskerville, R. L., & Barnes, R. J. (1996). An Empirical Comparison of a Hypertext-Based System Analysis Case With Conventional Cases and Role Playing. *DATA BASE, 27*(1), 58-77.

Kolb, D. (1976). Management and the Learning Process. *California Management Review, 13*(3), 21-31.

Leidner, D. E., & Jarvenpaa, S. L. (1995). The Use of Information Technology to Enhance Management School Education: A theoretical View. *MIS Quartely, 19*(3), 265-291.

Lucas, H. C., Jr. (1975). *Why Information Systems Fail.* New York: Columbia University Press.

Lyytinen, K., & Hirschheim, R. (1987). Information Systems Failures - a survey and classification of the empirical literature, Oxford Surveys in Information Technology (Vol. 4, pp. 257-309): Oxford University Press.

Margretson, D. (1991). Why is Problem-based Learning a Challenge? In D. Boud & G. Feletti (Eds.), The Challenge of Problem Based Learning (pp. 42-50). London: Kogan Page Limited.

Nulden, U., & Scheepers, H. (1998). What about failures? Suggestions for an alternative computing education activity. Failure & Lessons Learned in Information *Technology Management, 2.*

Oz, E. (1994). When Professional Standards are Lax - The CONFIRM Failure and its Loss. *Communications of the ACM, 37*(10), 29-36.

Ramsden, P. (1992). ***Learning to Teach in Higher Education*****. London: Routledge.**

Sauer, C. (1993). ***Why Information Systems Fail: A Case Study Approach*****: Alfred Waller.**

Schank, R. (1997). ***Virtual Learning: A Revolutionary Approach to Building a Highly Skilled Workforce*****. New York: McGraw-Hill.**

Senge, P. (1995). ***The fifth discipline*****: Doubleday Dell Publ. Group.**

Slavin, R. E. (1990). ***Cooperative Learning: Theory, Research, and Practice*****. Engelwood Cliffs, NJ: Prentice Hall.**

Warren, M. (1979). ***Training for Results: A system approach to the development to the development of human resources in industry*****. (2 ed.): Addison-Wesley.**

Fourth Paper

Thematic Modules in an Asynchronous Learning Network:

A Scandinavian perspective on the design of introductory courses

Urban Nuldén

Abstract

This paper discusses an educational philosophy and proposes a framework for structuring introductory courses in higher education. The philosophy is rooted in a Scandinavian tradition of social settings. Two elements are central in the philosophy: First, the notion of a thematic module (TM) which is a unit for studying a limited subject matter or topic. Second, asynchronous learning networks (ALN), which is the use of computer mediated communication for time and place independent collaborative learning. To evaluate the philosophy, a course, *"Introduction to Informatics,"* was designed and offered to forty-three business administration majors. Three central assumptions of the philosophy guided the design and evaluation of the course. First, thematic modules are appropriate for structuring an introductory course, second, asynchronous learning network is a viable environment to enhance thematic modules, and third, TM in ALN is a suitable approach for educators who wish to engage students and fellow educators in constructive and collaborative learning activities. To investigate the assumptions, both qualitative and quantitative data were collected and analyzed. The quantitative data gathered are very limited, but give indication for further research. The paper ends with a tentative framework for design of introductory courses using TM and ALN.

1. Introduction

Many educators believe in the immense potential of information technology (IT) and computers as learning tools. However, vital aspects are often neglected in these rather technology intensive discussions. To realize the potential of computers and other information technology, as tools for teaching and learning, we have to reconsider what we teach as well as how we teach. But most of all it is necessary to revise our understanding of how people learn.

Current transition to post-industrial society, information society, learning society, digital society or whatever we decide to call it, clearly reflects a change in what knowledge people should have in order to be capable actors in this new society. The question then is whether education, and especially higher education, is adapting to this change? The notion of life long learning, and learning to learn is as important in formal education as the task of acquiring the knowledge itself. From a pedagogical perspective, a (radical) change of educational practice is necessary to meet the demands from the new society.

The research is conducted in Scandinavia, where research on IT has certain characteristics that can be summarized in two main points. First its context as it is situated into a societal setting with democracy, special labor-market relationships, a concern for ethical issues, and a tradition for design of IT artifacts. Second, its diversity as there are many competing approaches mixed with openness and mutual respect. In Scandinavia, pedagogical research has a history of mainly quantitative research. This changed as phenomenography later came to be a main methodological approach. Marton (1992, p.253) describes phenomenography as a research approach for describing the limited number of qualitatively different ways in which a phenomenon is experienced, conceptualized, or understood, based on an analysis of accounts of experiences as they are formed in descriptions produced in research with other people. These characteristics of IT as well as pedagogical research influenced this research to a large extent.

The central concept in this paper is thematic modules (TM) which is the notion of structuring a course in self-contained and content-based modules focusing more intensively on process than on product. This is further discussed in section three. A second central aspect is the use of information technology in education. This is a frequent field of research

and until recently, research examining classroom use of computers consisted almost exclusively of experiments examining a specific application of a computer based instruction, video disk or interactive video (Leidner and Jarvenpaa 1993). The interest has been focused on the interaction between the student and some kind of computer artifact e.g., a software application. The focus is slowly changing towards computer mediated interaction and communication among students, and among students and teachers. The Virtual Classroom, learning environments and learning communities are notions commonly used in this form of education. Numerous universities have designed and developed their own applications of computer supported learning environments (see for instance Harasim, Hiltz et al. (1995) for a summary). Commercial products such as Lotus Learning Space and First Class are gaining popularity among educators, and there are also other World Wide Web-based alternatives. These environments are often referred to as Asynchronous Learning Networks (ALN). A central pedagogical as well as practical idea among the users of ALN's is collaborative learning at the time and place of the individual student convenience (Hiltz and Wellman 1997).

This paper discusses an educational philosophy with two central concepts—thematic modules and asynchronous learning networks. The philosophy was applied to design an *"Introduction to Informatics"* course stretching over ten weeks. Forty-three MBA students at a Swedish Business School participated in the course. The Business School had two requests. Not surprisingly, one was to keep the costs down; the other was that the course should utilize the potentials of information technology. From the perspective of the course coordinator (who also is the author) there were two reasons for applying TM and ALN in the design of this introductory course. First, an introduction to Informatics is requested by an increasing number of students with varied backgrounds. The department of Informatics needs to find an appropriate way to meet this demand. The department needs to find models to scale-up and still be able to offer courses with high quality. Second, our experiences of introductory courses are that students often perceive them as fragmented. A large number of topics and aspects are introduced in a very short period of time in introductory courses but usually very limited time is allocated for reflection. The following three assumptions are the core of the philosophy

and at the same time they serve as structure for the research discussed in this paper.

- **Thematic modules (TM) are a fruitful structuring philosophy for an introductory course.**
- **Asynchronous learning networks (ALN) are viable resources to enhance TM.**
- **TM and ALN are a suitable approach for constructivistic and collaborative learning.**

To investigate the assumptions, students and teachers involved in the course were surveyed. Note that this research is not hypothesis testing in the traditional sense. Rather it is a more pragmatic research from a methodological point of view.

The remainder of the paper is organized in the following sections. First, educational practice and technology are discussed. The section covers thematic modules and other approaches to structure educational activity and content. ALN as a concept is described together with a short review of related research. The next section describes the design and evaluation of an introductory course according to the philosophy. The following section proposes a framework for designing introductory courses using TM and ALN. Finally, the last section conclusions are drawn and further research is outlined.

2. Teaching, Learning and Technology

Memorable educational experiences are enriching, engaging and stimulating. Ideally, they help students to increase knowledge and skills, they provide them with a satisfactory feeling of accomplishment, and they challenge their worldview. But establishing an environment that engages students is no easy feat. A teacher centered lecture might be memorable, but challenges from the teacher and interaction among the students are usually more influential for the students learning. In this paper, learning is understood as a change in the way people understand the world around them, rather than a quantitative accretion of facts and procedures (Ramsden 1992). In other words, learning is something students do, not something that is done to them.

2.1. Approaches to Learning

A variety of models are used to characterize different paradigms of learning. Being somewhat categorical, these models are often classified as either behavioral or cognitive. The behavioral models are based on Skinner's theory about stimulus and response, whereas the cognitive models are based on cognitive information processing and more recently on collaborativism.

Traditionally the model of choice in education has been the objectivist model of learning (see for instance Leidner and Jarvenpaa (1993)). Basically, facts and information exist out there and the instructor acts as an intermediary who filters, selects and transmits the information to ignorant students. The dominating activities are active teachers presenting information to passive students, through lectures, and written material, such as textbooks. Students then provide the teacher with evidence of learning by recitation, orally or in written exams. At lectures, teachers ask questions and expect the student to provide an immediate answer, which is either right or wrong. The overall objective for the teacher is to produce, in the mind of the student, the necessary body of knowledge.

The objectivist model is criticized for stimulating surface learning (O'Neil 1995), knowledge reproduction and knowledge telling instead of knowledge building (Scardamalia and Bereiter 1993). Knowledge building, on the other hand, is a learning theory which is based on a constructivist/social cognitive worldview where knowledge is constructed as it fits the individuals' experience of the world (Harasim, Hiltz et al. 1995). Moreover, a knowledge building strategy treats the learner as an active participant, interacting with others in the group. This way the learner actively constructs knowledge by formulating ideas built on reactions and responses of others to the formulation into words. Therefore, as an alternative to objectivism, a constructivist model of learning is put forward. The constructivist model stresses the crucial relationship between new experience and what is already known. Learning develops through encounters with new information that is different enough to be stimulating, but not so alien that it can not be assimilated into the learner's mental structures that represent her present state of understanding (Watson 1996). Real learning must build on the students' own knowledge, needs and interests. The objectivist and the constructivist model can also be

classified as surface and deep approaches to learning (Ramsden 1992, p.46). This is summarized in table 1 below.

Surface learning (objectivistic) – Intention to complete task requirements.	Deep approach (constructivistic) - Intention to understand.
- Focus on the signs (e.g., words and sentences of the text, or unthinkingly on the formula needed to solve the problem). - Focus on unrelated parts of the task. - Memorize information for assessments. - Associate facts and concepts unreflectively. - Fail to distinguish principles from examples. - Treat the task as an external imposition. - External emphasis: demands of assessments, knowledge cut off from everyday reality.	- Focus on what is signified. (e.g., arguments and concepts applicable to understand and solve the problem). - Relate previous knowledge to new knowledge. - Relate knowledge from different courses. - Relate theoretical ideas to everyday experience. - Relate and distinguish evidence and argument. - Organize and structure content into a coherent whole. - Internal emphasis: a window through which aspects of reality become visible, and more intelligible.

Table 1: Different approaches to learning (from Ramsden, 1992, p.46).

Writings on constructive learning have altered in their perspective over the last twenty years to include more than the mental activity of individuals in learning (Watson 1996). Social interaction among the learners is added to the constructivist model and it becomes collaborative. Collaborative learning refers to an activity where two or more people work together to create meaning, explore a topic, or improve skills (Harasim, Hiltz et al. 1995). From a practical perspective, collaborative learning consists of activities using peer interaction, evaluation, and cooperation, with some structuring and monitoring by the educator. This collaborative

model of learning has frequently been used as the basis for understanding and exploring learning. The basic premise underlying this is that learning emerges through shared understandings of multiple learners (Leidner and Jarvenpaa 1993). The essence of the model is that active participation is critical to the learning process and that learners have knowledge valuable to other learners. Learning is sharing, and the more that is shared the more is learned. The constructive and collaborative models are combined in a, what we can call, reflective model of learning. From the above, it is claimed that our conception of learning is changing from behavioral to cognitive and constructive; from individual to collaborative; and from objectivist to reflective.

In the objectivist model of learning the role of the educator is to provide or transmit knowledge. In the constructive and cooperative models, on the other hand, the educator is a facilitator and mediator of the learning process. This is often described as scaffolding which is the educational term that describes this guidance and the support the teacher provides to the learner (Jackson 1996). Clearly, teaching and learning is migrating from teacher centered to learner centered. Let me give a few examples of such activities. First, problem based learning (PBL), where "People learn best when engrossed in the topic, motivated to seek out new knowledge and skills because they need them in order to solve the problem at hand. The goal is active exploration, construction and learning rather than passivity of lecture attendance and textbook reading. The major theme is one of focusing around a set of realistic, intrinsic problems" (Norman and Spohrer 1996). Second, learning-in-doing (based on Kolb's learning-by-doing) where "Learners are increasingly involved in the authentic practices of communities through learning conversations and activities involving expert practitioners, educators, and peers" (Pea 1993). Third, related to the previous, experiential learning where students work in small groups, and what is learned is directly related to what happens in the group and how it happens. Fourth, open discovery, where the "Students have responsibility for determining what to learn, as well as when and how to learn it" (Swanson, Case et al. 1991). And fifth, the notion of the virtual classroom where the "Computer-mediated environment supports a collaborative learning process that can exceed that of the traditional classroom, a process in which students and instructors are actively

involved in creating and carrying out learning activities together" (Hiltz 1994).

These five are claimed to be examples of different reactions to the objectivist model of teaching and learning. Whereas they are different in many ways, they still share some basic assumptions. First, these approaches rely on engaged and motivated students. Students learn when they are engaged in active exploration, interpretation and construction of ideas and products with a variety of resources (Hawkins 1993). Second, it is collaborative learning, which is a highly interactive process with collective responsibility. Third, computing technology is viewed as an important resource in enhancing educational activities. It should be noted that learner centered approaches are also criticized by both students and teachers. However, this discussion is beyond the scope of this paper.

2.2. Curriculum and Structuring of Courses

Designing a good course structure is not easy. Clear (1997) suggests a number of models for curricula integration. Some possible paradigms of structuring an introductory course are given in the ten different approaches to structure a curriculum. Even if the objective of them is to provide structure for larger units than courses, they do provide some valuable input in structuring shorter units such as courses.

The fragmented model	***"The traditional model of separate and distinct disciplines, which fragments the subject areas."***
The connected model	***"Within each subject area, course content is connected, topic to topic, concept to concept, one year's work to the next, and relates idea(s) explicitly."***
The nested model	***"Within each subject area the teacher targets multiple skills: a social skill, a thinking skill, and a content specific skill."***
The sequenced model	***"Topics and units of study are re-arranged and sequenced to coincide with one another. Similar ideas are taught in concert while remaining separate subjects."***
The shared model	***"Shared planning and teaching take place in two disciplines in which overlapping concepts or ideas emerge as organizing elements."***
The webbed model	***"A fertile theme is webbed to curriculum content and disciplines: subjects use the theme to shift appropriate concepts, topics and ideas."***
The threaded model	***"The metacurricular approach threads thinking skills, social skills, multiple intelligences, technology, and study skills through the various disciplines."***
The integrated model	***"This interdisciplinary approach matches subjects for overlaps in topics and concepts with some team teaching in an authentic integrated model."***
The immersed model	***"The disciplines become part of the learner's lens of expertise: the learner filters all content through this lens and becomes immersed in his or her own experience."***
The networked model	***"Learners filters all learning through the expert's eye and makes internal connections that lead to external networks of experts in related fields."***

Table 2: Ten different paradigms for curriculum design (Clear 1997).

On the other hand, looking at the different activities within the course, table three is a classification of components within a single course (adapted from Collis (1997)).

1	General (enrolling, reading syllabus, obtaining and reading course organizational information; travelling to the course, picking up material, waiting for lectures to begin, etc.)
2	Lectures/Presentations
3	Group discussions/Seminar-style sessions
4	"Learning events" (i.e., field trip, guest lecture)
5	Private communication with instructor and peers
6	Self-study and practice (supervised or non-supervised)
7	Individual project (major course assignment, done individually)
8	Group project (course assignment, done as part of a group)
9	Testing and assessment

Table 3: Components in a course.

In this research it is suggested that large introductory courses often are designed according to the sequenced model, with lectures, self-study and practice as the main building blocks. The aim of introductory courses are often to give students the "big picture" or overview of a field. This is questioned by Laurillard (1993) who clearly describes this as an educational problem, which is obvious in introductory courses.

> ***"The lecturer must guide this collection of individuals through territory the students are unfamiliar with, towards a common meeting point, but without knowing where they are starting from, how much baggage they are carrying, and what kind of vehicle they are using. This insanity. It is truly a miracle, and a tribute to human ingenuity, that any student ever learns anything worthwhile is such a system" (ibid p.3).***

A central claim in this paper is that introductory courses have specific properties no matter what area or topic they are to cover. Our reason is the

following properties that we find in introductory courses. Introductory courses are usually large heterogeneous classes. Students have very different backgrounds and their reason for taking the course varies, and they surely have very different levels of motivation. We suggest an alternative view of introductory courses.

It should be stressed that this paper does not suggest a third approach to learning. Rather the aim is the design of introductory courses which engage students in activities with a focus that is moving from the objectivistic towards the constructivistic.

2.3. Thematic Modules

In the research described in this paper, the notion of thematic modules (TM) is used to describe the modular structuring of a course and the course content. A TM is defined as longer than lessons and shorter than a course, and it is suggested that in a content-based approach, the module constitutes the basic unit of study. Content-based modules are useful for experimenting with minimal changes in existing courses and at the same time focus more intensively on process-methodologies. TM can, to some extent, be viewed as a reaction to the fragmented and the sequenced model above.

From a pedagogical perspective, thematic modules share many characteristics with problem based learning (PBL). As in PBL, each TM contains a number of distinct phases. First, there is an introduction of a topic or issue. In PBL this is done through a vignette, which can be anything from a single paragraph to a twenty-page case study. In PBL the purpose of the vignette is to direct a group of students to a problematic situation or phenomena. The group then defines what aspect of the problem they find most interesting to work with. In other words, they become *problem owners*. The result of the group work is documented and presented in an appropriate way. In TM the first phase is a lecture that ends with a challenge for the students. It should be emphasized that the lecture not necessarily is a lecture in the traditional sense. For instance, it could be a video or a panel debate. This is described more in detail in section 3.1 below.

2.4. Asynchronous Learning Networks

This section describes asynchronous learning networks (ALN) and discusses implementations and related research. The paper presumes that

the reader is fairly familiar with the concept of asynchronous learning networks. However, a brief recapitulation of the core concepts is made below.

Implementations of ALN utilize different tools for computer mediated communication (CMC). In this way, ALN can be understood as an IT infrastructure supporting educational activity. This infrastructure includes email, bulletin boards and news groups, synchronous chat systems, computer conference systems, group decision systems, and most recently pages on the World Wide Web (WWW) (Hiltz and Wellman 1997). The central pedagogical idea in an ALN is collaborative learning at the time and place of the individual learner's convenience (Bourne, McMaster et al. 1997). ALN is a special software structure purposely designed to support collaborative learning (Hiltz and Wellman 1997). An ALN is in other words a teaching and learning environment located within a CMC. ALN's are best at enhancing educational activities when they serve as a way to create a feeling of a group of people learning together and to structure and support carefully planned collaborative learning activities (Hiltz and Wellman 1997). Research about ALN's has been conducted for more than a decade. Well known is the work done at New Jersey Institute of Technology with the Virtual Classroom as a trademark. Scandinavian research on ALN's is to some extent following this tradition. However, it is suggested that Scandinavian use of ALN is slightly more towards facilitating interaction among the students, that is, horizontal interaction. Whereas, research outside Scandinavia have a tendency to use and study ALN as a tool to deliver instruction.

There are also problems and disadvantages in using ALN's. Anonymity and issues related to the fact that people do not meet face-to-face introduce initial problems with many ALN based courses and other activities. Many students find it easy to postpone attendance when they are busy with other things. This can easily turn into falling seriously behind. It is also shown that despite good intentions when structuring a computer conference there is an extensive risk of information overload. Early and enthusiastic course activity in the beginning of an ALN course might result in some students overloading others by writing and posting voluminous and numerous messages.

In this research, *forum* is interchangeably used together with ALN, and in some cases conference system. The term forum was exclusively

used when talking with the students. This is also what students used in communication with each other.

3. Applying TM in ALN

This section is divided into two parts. The first part describes the design of an introductory course in Informatics according to the philosophical ideas outlined above. The second part describes how the course later was evaluated.

3.1. Designing the Course

"*Introduction to Informatics*" as a five credit points course was offered to forty-three guest students from China, completing their final year of an international MBA program at a Business School at a Swedish University.

The Informatics course was scheduled to last over ten weeks and include both theoretical aspects of Informatics as well as some hands-on exercise. In other words it is not a computer literacy course. In the previous year, a similar course had been offered to the students. However, at that time, the aim was to introduce the students to more traditional aspects of computer use in organizations, i.e., computer literacy. This created some expectations among the students. This is however understandable as there are emerging definitions of what constitutes computer literacy, information literacy and information technology literacy (see for instance Mueller (1997) for a discussion). To meet the demand from the students we asked them to take part in four workshop sessions, each two hours long, with an emphasis on practical work with the computers and related software applications.

Fifteen teachers were approached and asked if they could be responsible for one of the modules. Eight of them agreed to participate and were engaged in the course, one for each module. Some of the educators were given the topic for the module, others were asked to suggest their own. The reason was that some of them do research in a variety of fields, and some research was more difficult to pinpoint. They were offered standard payment for their efforts that would include two hours of lecture, and a total of three hours (at the time of their convenience) of electronic discussion in the ALN.

The eight teachers received the same instructions through a personal briefing. They could fairly freely lecture about aspects or portions of their own field of expertise. However, the purpose of the lecture should not be a

summary of state of the art research within the specific field. The reason for emphasizing this instead of recommending what the teacher should do was the idea that the individual teacher should choose her own style for the lecture. The intention was not to have all the teachers do a lecture that was uniform in format. Neither should the lecture be a summary of the theories or models dominating the specific research field. The purpose of the lecture was to make the students interested in the teacher's field of research. Learning is most effective when students are truly engaged. The lecture should challenge the students and initiate acts of knowledge discovery. If possible, they should also try to relate the module to China in some way. Many of the teachers managed to do this in the form of cases and anecdotes. The author emphasized to the eight educators that:

> **"After your lecture and from the students own interest, fifty, if not seventy, per cent of the class should go straight to the library, or to a computer connected to the Internet to search for more information about what you just talked about."**

The modules came to be strongly related to the eight teachers' fields of research, and were the following:

Topic or field	Short description of topic in each module	Discussion initiation
CSCW	Computer Supported Cooperative Work.	Two questions.
Workflow	Workflow and related technology for coordinating and structuring work.	Summary of the lecture and two questions.
The Internet	Electronic commerce. Cases of different organizations and how they have employed the Internet.	Posted two questions in the forum.
DSS	Decision Support System and different aspects of decision making in organizations.	Case with follow up questions.
IT in Health Care	Tele-radiology, computer based x-ray was presented. Ethical issues about computer use.	Questions.
Informatics	A philosophical lecture about changes and the information society we are entering.	One question.

IS Management	**Information Systems and Information Resource Management (IRM).**	**Examples followed by two questions.**
IT Management	**It is not only use of the technology but a complex management situation.**	**One question.**

Table 4: The topic of the eight modules and what each lecture used to initiate the thematic week to come.

No textbook was selected for the course, instead the week before their module, each educator was to provide one or two *good* articles to be distributed to the students. The students were asked to read and discuss the articles (electronically or traditionally) prior to the lecture. The module started with a two hour lecture on Monday morning, the first day of each module. The educators were instructed to end the lecture with something that would initialize the computer-mediated discussion as discussed above. Depending on the personality of the educator and their teaching style, they were requested to end the lecture with questions that students could discuss or answer online. They could also use longer cases that were presented online, and ask the students to work with a specific aspect of the case, individually or in a group. For the more radical educator, provocation was suggested as an alternative. As the students came from a culturally very different part of the world this was considered a difficult task to perform with predictable and successful outcomes. The teachers were then obligated [and paid] to participate in and facilitate the electronic discussion.

Sending email to the teachers was discouraged. Instead, the students were encouraged to use the ALN for open interaction with the educators and really use them as a resource of expertise for the whole group. Thereby, the students became partners in deciding what to cover in the module. By Sunday afternoon the module ended. The students were then required to summarize the discussion that had taken place during the module in about half a page. When this was completed the module was over and the next module could start the following day. The structure of a module is summarized in the box below.

1. The module starts with a two hour lecture in the format of choice of the educator.

2. The lecture ends by initialization of the ALN part of the module.

3. The educator participates in and moderates the electronic discussion.

4. By Sunday afternoon, the students were required to post a summary of their understanding, or experience, of the discussion during the past week, i.e., module.

Box 1: Basic structure of a thematic module.

The author met with the students for an introduction lecture the first day of the course. The purpose of the course as well as the modules and the ALN was demonstrated and explained. The lecture was followed by a two hour workshop where the students were introduced to the conference system used in the course. The main CMC tool used in the course was a WWW-based commercial conference system and e-mail was used in some situations. Only the very basic functionality of the conference system was used. Figure 1 is a screen of the conference system's interface.

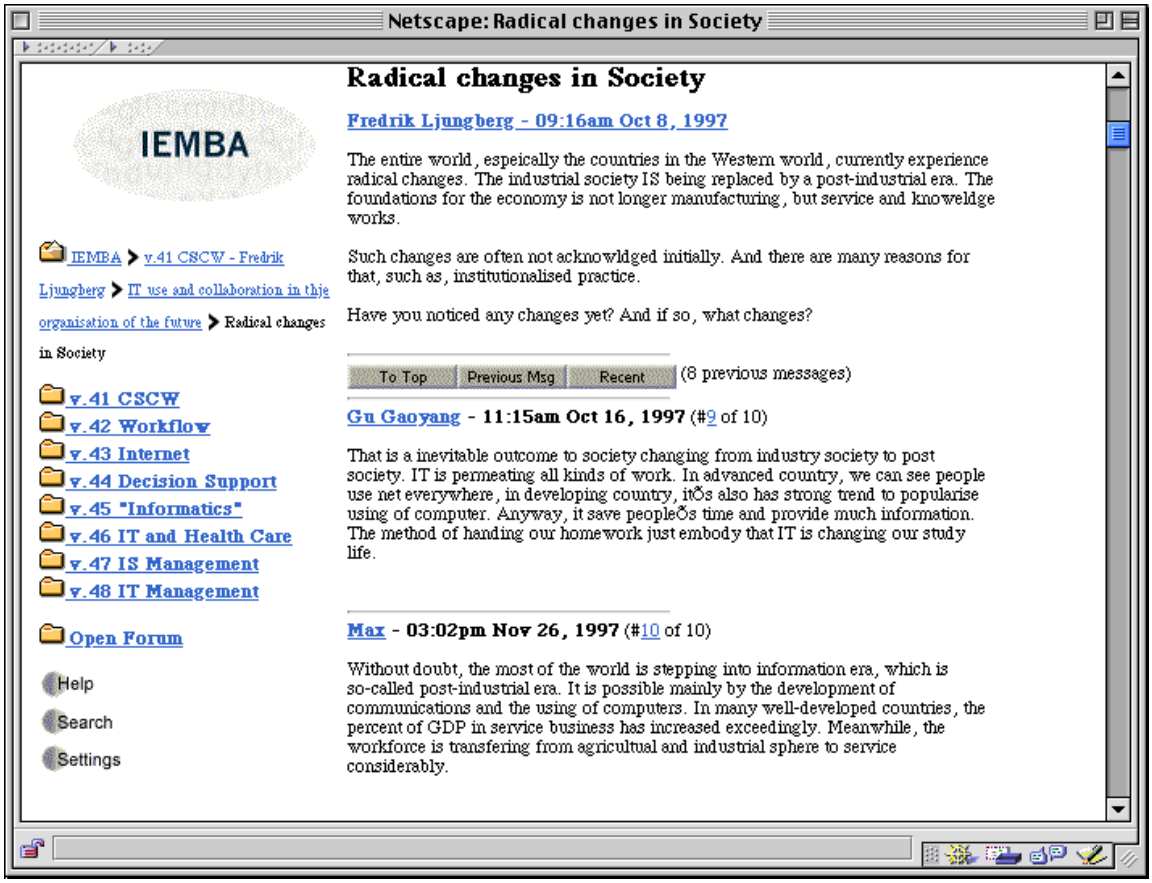

Figure 1: A screen from the conference system used. The upper left side shows the top level where each module has it own discussion. The bottom left side of the screen shows the links to the open forum where the students freely discuss or socialize. The right side shows an actual discussion where the educator raises some issues related to his module.

3.2. Evaluating the Course

Two surveys were conducted with the students and semi-structured interviews were conducted with the teachers involved in the course. The motivation for using surveys with the students and interviews with the teachers was partly practical. However, the interviews provided valuable comments and opinions from the teachers that probably not would have been covered in a survey. The results of the final comprehensive exam were also a valuable input for evaluating the course design.

3.2.1 The Students

The forty-three students participating in *"Introduction to Informatics"* were surveyed twice, mid-course and after the last session of the course.

The instrument used for the first survey was a single page with a positive and a negative column. Forty-one students completed this. The students were asked to write down at least three positive things and three negative things about the course. The responses were coded by identifying keywords in sentences. Two negative aspects and two positive aspects came out clearly.

The absence of a textbook was the most negative thing about the course at this stage. Apparently, the researcher underestimated the importance of the textbook. The textbook provides a strong structure for how the students approach planning and conducting their studies. Many of the teachers were also subjects for discussions about textbooks.

The separate articles handed out did not provide the structure in advance since they were handed out continuously at eight different occasions. Binding the articles together and adding a foreword, and distributing them at the first lecture can be a solution to overcome this problem.

The second negative aspect was that there was too little time at the computers. A large group of the students had expected the course to be a hands-on course with emphasis on applications such as word processing and spread sheets. The description in the course catalogue clearly emphasized that the course did not cover this.

This was handled by offering them four two hour workshops with exercises and support by tutors. However, when facilitating parts of the workshops, it was obvious that many of the students were fairly advanced users of computers., especially web-searching and communication such as e-mail and chat.

The most positive thing was that the course was different in format. The format explicitly invited interaction with peers and educators. The horizontal interaction, student-student, was new to most of the students. Many students showed in the survey that they had reflected on their own responsibility for the learning process.

The time and place independence was the second positive aspect about the course. Even though very few of the students had a personal computer or access to computers apart from the computer labs they appreciated the possibility to work at the time and place of their choice.

The instrument for the second survey consisted of five sections of questions. Forty students, 24 male and 16 females, with an average age of 29 handed in complete surveys. First the course as a whole; second, their

opinions about each of the modules, third, their computer skills, fourth, the strengths and weaknesses of the course, and fifth, some questions of a demographic nature. Most of the questions were multiple choice on a seven point Likert scale. As the size of the population was very limited statistical analysis was not conducted in any larger scale. Table 5 summarizes the results of some of the issues raised in the second survey.

Question	Mean	Std
This course has been … (1) very ordinary – (7) very unique	5.0	1.5
This course has been … (1) not fun at all – (7) A great deal of fun	4.7	1.3
Compared to other courses, I spent .. (1) less time – (7) more time	4.3	1.3
I believe this course helped to increase my understanding of IT … (1) not at all – (7) very much	5.9	1.3
Did this course meet your expectations (1) not at all – (7) totally	4.5	1.3
I used our WWW based forum (1) never – (7) every day	4.5	1.0
I believe the forum contributed to the course as a whole … (1) not at all – (7) very much	5.5	1.0
Did you read other students contributions in the forum (1) never – (7) every day	4.3	1.2
Did you learn anything from reading the other contributions (1) absolutely – (7) absolutely not	4.2	1.3
I believe my computer skills to be that of a(n) (1) beginner – (7) expert	3.8	1.0
I believe the hands-on exercises increased my skills (1) not at all – (7) very much	4.5	1.1

Table 5: Summary of descriptive statistics.

Despite limited data, the correlation between some variables was tested. Strong correlation (r = 0.62) was found between: "This course has been … (1) not fun at all – (7) a great deal of fun" and "This course has helped to

increase my understanding of IT … (1) not at all – (7) very much." This can be interpreted as an evidence that engagement and the "fun factor" is important for learning. Correlation (r = 0.35) was also found between: "I consider my computer skills to be that of … (1) a beginner – (7) an expert" and "I used our WWW based forum … (1) never – (7) everyday." It is suggested that this indicates the importance of sufficient initial training with the ALN to ensure interaction among the students. Of course, the facilitation of the educator is equally important.

The final exam is also an indicator of the outcome of the introductory course. The exam consisted of eight open-ended questions related to the eight modules. The grades were completely based on the exam; 19% of the students received high pass and 81% pass in a three grade scale. In other words, no student failed the final comprehensive exam.

Personal conversation with the students, both face to face and via e-mail, did reveal interesting aspects. The most striking issue was a small group of students coming up to me after handing in their final exam the last day of the course. After some phrases of greetings, one of them asked: "Why did you give us this exam? We think it interferes with the ideas you have about the modules."

Summing up the student response it is suggested that the students found the course satisfactory. Most of them posted the required report at the end of the module. Some horizontal conversation among the students took place. Many students viewed the lectures as lectures with a "covering" overview, not as points of departure for further learning. The ALN used provided the necessary infrastructure for the idea of thematic modules. This was the first encounter with student-centered education for most of them. Therefore, the result from the evaluation must be considered very tentative.

3.2.2. The Teachers

The teachers were approached in an informal semi-structured interview some time after the course had finished. The interviews started by asking them to recapitulate the instructions they had received prior to their module. Their responses to this served as structure for the remainder of the interview. The interviews lasted between twenty minutes and one hour. Notes were taken during the interviews and later analyzed by identifying frequent keywords. The frequency of the keywords then guided

the structure of the remainder of this section in that aspects (keywords) raised by more teachers are listed first.

Only one of the teachers asked me to refresh his memory about the instructions for his module and one teacher was somewhat critical of the instructions that he had received. He did not know what he was expected to do. However, the instructions appeared to be clear for most of the teachers, both the lecture and the expected on-line activity. Below is a list of aspects raised by the teachers during the interviews.

First, the heterogeneous group was raised by almost all of them. "I didn't know how much they knew about the topic, or other related concepts." This is, however, one of the generic pedagogical problems in all educational activity. With limited knowledge about the group, there is really not any platform for more provocative questions. "I do not intend to insult them" as one teacher put it. Related to the background of the students and the terminology, some of the teachers found using English during lectures to be a problem as this was not their first language.

Second, "I am in the middle of a very hectic period at the moment" was a type of phrase most of the teachers used to describe their workload. Months ago, when they were engaged to participate and to be responsible for a module, the planned time schedule with two hours of lecture and three hours in the ALN seemed not to be a problem. However, when the module started, most of them found it difficult to allocate the time for the ALN based discussion. As one teacher put it: "We're all optimistic when it comes to time."

Third, the available time. Two hours for a lecture were perceived as a short time to give background according to the teachers, "but on the other hand, who has time for longer sessions?" However, it seems as if many of them tried to give an overview of their field rather than to focus on introducing and creating an interest for the field. It seems as if it is difficult to challenge and create an interest in a two hour session.

Fourth, the problem of responsibility. One teacher put it very blunt. "I do not care about temporary students but if I have my own course it is different." He continued to be critical. "The attitude is a big problem. Most teachers try to do as little as possible. The incentive system is non-existing. Nobody cares what I am doing. Many of my colleagues have the same opinion, they do it and then they do not care about it any more. Teaching is just a way to finance research." Other teachers are critical to the quality

and standard of many courses, but at the same time, they will not talk to others about change. "It is not my responsibility." One teacher is changing his way of teaching, but he will not tell others to change.

Fifth, being active. Initially many of them stated that they had been active during the module. A quick glance in the log-file of the conference system showed that only very few messages were posted by teachers. When facing the teachers with this fact, they quickly admitted that they had logged in as "guests" to make sure that students were "on the right track." One teacher used e-mail to push individual students to raise issues for further discussion in the ALN.

Summing up the teachers' responses, it is clear that they understood the ideas and, at least to some extent, found them viable for their purpose, but there is not an institution around it to make it work. The role of the course facilitator was questioned, the suggestion was that professors should have lectures, and facilitators, such as teaching assistants, should participate in the discussion part. Pedagogical trends come and go according to a senior professor and he concluded: "There are some generic standard building blocks of communication and educational activities we are elaborating with in different orders and sequence. But, what we are doing is almost always the same."

4. Discussion

This paper has discussed a philosophy for designing introductory courses. The philosophy was evaluated by designing and realizing an introductory course in Informatics. In this section the philosophy and the results from the evaluation serve as the starting point for proposing a framework for structuring introductory courses. Let us first return to the assumptions made in the introduction and discuss them in the light of the design and evaluation of "*Introduction to Informatics.*"

- **Thematic modules (TM) are a fruitful structuring philosophy for an introductory course.**

Analyzing the collected data and reflecting on the experience from the course it is claimed that this is a valid assumption.

- **Asynchronous learning networks (ALN) are viable resources to enhance TM.**

The results suggest this to be a feasible combination.

· **TM and ALN are a suitable approach for constructivistic and collaborative learning.**

This needs to be further investigated.

4.1. Proposing a Framework for TM in an ALN

Lessons learned from the design and implementation an introductory course with the philosophy of TM in ALN serve as a starting point for proposing a framework for designing and coordinating introductory courses. At this stage, the framework consists of seven guidelines which all to be elaborated further.

- **First, the role of the course facilitator is very central. The facilitator must be an active participant in the different activities. Both collaborative learning and ALN require taking initiative and being active, but it is still the responsibility of the educator, e.g., facilitator, to create the choices open to them.**

- **Second, teachers involved must receive a thorough introduction to the purpose of the module. It is very easy to fall back on a traditional lecture structure where the lecture is a closed unit with a start and an end. The lecture in a thematic module on the other hand does not include an end, it is only a starting point.**

- **Third, the importance of varying starting points for the ALN portion must be emphasized. There is a slight risk that all modules in a course will have the same format. This might introduce an undesired routine behavior among the students.**

- **Fourth, teachers should not automatically be responsible for the ALN based discussion. Most introductory courses are fairly large and moderating a discussion with say eighty students is not really possible. Instead, teaching assistants (TA) should be engaged as facilitators in smaller groups. The TA is responsible for facilitating the discussion but does not assess the students participating in the discussion.**

- **Fifth, the size of the groups. From the above, it is obvious that a group of forty students is not feasible. In PBL a group of eight is usually recommended. However, this is a question about resources. It is possible to facilitate high quality discussions with up to twenty students, but this is of course depending on several factors, mainly of economic nature.**

- **Sixth, the assessment system must be an integrated part of the whole course. Active participation is a main goal in a course structured as TM, which should be rewarded by the incentive system, e.g., credit.**

Therefore, a final comprehensive exam should only be a limited input for assigning the final grade. But, the TM based course is probably better without the comprehensive exam.

- **Seventh, the data stored in the log generated by the conference system as well as other applications in the ALN should be used to monitor the activity taking place in the ALN. Visualization of this data can provide the teaching assistant, the teacher and the course coordinator with valuable information for supporting the activity that is going on.**

5. Conclusions and Further Research

This paper has discussed teaching, learning and technology and with that as a background, proposed a structuring philosophy for introductory courses: Thematic Modules in Asynchronous Learning Networks. The philosophy was implemented in an introductory course in Informatics and evaluated. The result of the evaluation then served as a starting point for a proposed framework for structuring introductory courses. The conclusion is that the philosophy has potential for introductory, but further evaluation of mainly learning outcomes is needed.

The main limitations of this study are the characteristics of the group, that is, guest students from China, and the limited data collected. The language used in the course was English, which is neither the students nor the lecturers' first language. Therefore, generalization of the results to other pedagogical settings should be seen as limited. However, the results from this study provided direction for further research.

Informed by the findings in this research, we are currently designing the second version of an *Introductory course in Informatics*. The course is offered to second year undergraduate business administration majors. One hundred students are expected to participate, five teaching assistants will facilitate them, and nine lecturers will initiate one module each. Whereas the students in the research reported in this paper were Chinese guest students, the group for the second course will be regular students. Regular in the sense that they are part of a full BA program and the language used in the course will be Swedish, that is the first language of both students and lecturers. The author is currently preparing the lecturers involved through individual meetings where both content and form of the module is discussed. Each lecturer will start their module with the slide '*What is Informatics*' which is given to them. How each lecturer will initiate the ALN part of the module is also thoroughly discussed with each lecturer.

The lecturers are faculty at the Informatics department, except for two who are IT professionals from the industry. The teaching assistants are also prepared for their role in the course. They will participate in a seminar with the author to discuss issues related to their facilitating role, but mainly to learn about the different possibilities with the ALN, such as voting and group editing. Literature of Ramsden (1992) and Harasim et.al (1995) support the preparation of the TA.

The course coordinator (author) met with the students who will participate in the course to make sure all students had access to networked computers. More than 75% of the group of about 100 students had computers with modems at home. This is certainly looking promising. The first 'introductory' lecture of the course will be given five times. That is, each of the five groups of twenty students and one teaching assistant will meet individually with the course coordinator. After the meeting the TA will gather the group for an informal meeting to discuss the modules to come, but also how the TA will facilitate the group using the ALN. The following ten lectures will only be given once with all one hundred students at the same time.

The results of the implementation of the second introductory course in Informatics following the philosophy of TM in ALN will be reported at a later date.

6. References

Bourne, J. R., E. McMaster, J. Rieger and J. O. Campbell (1997). "Paradigms for On-Line Learning: A Case Study in the Design and Implementation of an Asynchronous Learning Networks (ALN) Course." Journal of Asynchronous Learning Networks 1 (2): 38-56.

Clear, T. (1997). "Coupling Among Disciplines: Some Curriculum Paradigms." SIGCSE Bulletin 29 (4): 14-16.

Collis, B. (1997). "Pedagogical Reengineering: A Pedagogical Approach to Course Enrichment and Redesign With the WWW." Educational Technology Review (8): 11-15.

Harasim, L., R. Hiltz, L. Teles and M. Turoff (1995). Learning Networks - A Field Guide to Teaching and Learning Online, The MIT Press.

Hawkins, J. (1993). "Technology and the Organization of Schooling." Communications of the ACM 36 (5): 30-35.

Hiltz, S. R. (1994). The Virtual Classroom: Learning Without Limits Via Computer Networks. Norwood, NJ, Ablex Publishing Co.

Hiltz, S. R. and B. Wellman (1997). "Asynchronous Learning Networks as a Virtual Classroom." Communications of the ACM 40 (9): 44-49.

Jackson, S. L., S. J. Stratford, J. Krajcik and E. Soloway (1996). "A Learner-Centered Tool for Students Building Models." Communications of the ACM 39 (4): 48-49.

Laurillard, D. (1993). Rethinking University Teaching - A framework for the effective use of educational technology, London. Routledge.

Leidner, D. E. and S. L. Jarvenpaa (1993). "The Information Age Confronts Eduation: Case Studies on Electronic Classrooms." Information Systems Research 4 (1): 24-54.

Marton, F. (1992) Phenomenography and "the art of teaching all things to all men". Journal of Qualitative Studies in Education, 5, 253-267.

Mueller, N. (1997). "Missing the competitive advantage boat." Managing Office Technology 42 (1).

Norman, D. A. and J. C. Spohrer (1996). "Learner-centered education." Communications of the ACM 39 (4): 24-27.

O'Neil, M. (1995). Towards a Model of the Learner in Higher Education: Some Implications for Teachers. Research, Teaching and Learning in Higher Education. B. Smith and S. Brown. London, Kogan Page Limited: 117-124.

Pea, R. D. (1993). "The Collaborative Visualization Project." Communications of the ACM 36 (5): 60-63.

Ramsden, P. (1992). Learning to Teach in Higher Education. London, Routledge.

Scardamalia, M. and C. Bereiter (1993). "Technologies for Knowledge-building Discourse." Communications of the ACM 36 (5): 37-41.

Swanson, D. B., S. M. Case and C. P. M. e. van der Vleuten (1991). Strategies for Student Assessment. The Challenge of Problem Based Learning. D. Boud and G. Feletti. London, Kogan Page Limited: 260-273.

Watson, J. (1996). Reflection Through Interaction: The Classroom Experience of Pupils with Learning Difficulties. London, The Falmer Press.

Fifth Paper

Computer Support for Formative Assessment

Urban Nuldén

Abstract

This paper describes research investigating examination of business students. The overall goal of the research is the design of computer application supporting collaborative learning and formative assessment. The question guiding the research presented in this paper was: How can computers support examination of business students? To approach this question, the research was conducted in three phases. The first phase investigated business students' perception of examination. The methodology applied was data collection through a survey. Statistical analysis and interpretative content analysis were performed. The second phase, informed by the first phase, was the design and implementation of two types of computer based tools for examination. The first type is based on the notion of mandatory participation, and the second is based on the concept of peer review. In the third phase, the two designs were evaluated in a course with eighty business students. The main findings are the following: The first phase showed a diverse perception of examination among the students. Mandatory active participation in computer-based discussions combined with peer review of reports is claimed to be a viable approach for examination in a Business School environment.

1. Introduction

It is well known that the way students are examined has a very strong impact on their choice of strategy for studying and hopefully learning. To put it somewhat bluntly, if the students perceive that their learning will be measured in terms of reproducing facts or implementing memorized procedures, they will most likely adopt approaches that prevent real and deep understanding (Ramsden 1992). Traditional forms of examination in higher education have long been criticized for being destructive to the process of learning and, as a consequence of this, alternative forms for conducting examination have evolved. Examples are verbal examinations and different types of mentor-like relations between educators and students. However, many of these alternative forms rely heavily on resources, such as people and time, which clearly many institutions are lacking today. Sticking out the neck a bit, in this paper it is claimed that one resource that is not lacking at universities today are students' and teachers' access to computers and networks. Looking back just a few years and comparing the situation then with the current one, the number of students with access to computers, either their own, the family computer, computers at public institutions such as libraries or university labs, has increased substantially. Of course, this is not completely true for all universities; many universities and departments are struggling in their search for viable solutions to provide computer access to their students.

There are numerous studies showing that even if good results have been achieved in one form of examination, the same students rarely perform as well if they are faced with more challenging forms of examination (Laurillard 1993). This implies that students can achieve very good results in examinations, and still exhibit fundamental misunderstandings. See for instance Dahlgren and Marton (Dahlgren and Marton 1978) for research in economics understanding.

With information technology widely available in schools, it is not surprising that many educators are looking into the possibilities with the technology to, at least to some extent, overcome the problems of assessing students' learning through examination. Nevertheless, whereas the technology offers possibilities, there are also problems. Therefore, the aim of the research presented in this paper is to show how networked computers can be used in conducting alternative forms of examination of

business students. The research was conducted in three phases. In the first phase, approximately 370 business students were surveyed about their perception of examination. The result from the analysis of the survey served as input in the second phase, which was the design and implementation of two forms of computer supported examinations. They were, mandatory participation in an asynchronous structured computer based conference (MPE), and writing and peer reviewing reports in an open computer based environment (PeeR). In the third phase, the two designs were evaluated in an *Introduction to Informatics* course offered to eighty undergraduate business students.

The reminder of this paper is organized in the following sections: First, in the section Learning and Teaching, collaborative learning and formative assessment is discussed since it serves as a theoretical foundation for the research. This is followed by an outline of the research conducted in three phases and the methodological approach chosen for each of the phases. The next section discusses the results. Implications for educational practice and further research are proposed in the last section.

2. Learning and Teaching

This section aims to give a brief theoretical background to the conducted research. Two concepts serve as the theoretical starting point for this research, collaborative learning and formative assessment.

2.1. Collaborative Learning

It is not too controversial to claim that there is currently a shift concerning the focus of higher education. This shift can be described as going from teaching specific knowledge to working with the important skills of 'learning to learn.' Being able to continuously acquire new knowledge in a changing world is a core competency today, and will be even more important tomorrow. In a Business School context, educating individuals for tomorrow's business in the *information society* is certainly different from what has been done in the past. An astounding example of this is how the Internet has reshaped several areas of business in just a few years, and this has just started.

As a consequence, more and more educators in higher education are influenced by alternative understandings of educational and learning processes. Being a 'sage on the stage' is not an obvious choice for the teacher today. Rather, many of them choose to be a 'guide on the side' by

applying notions such as collaborative learning and horizontal learning when designing learning activities and building learning environments.

In such a learning environment, it is assumed that students are likely to learn as much from each other as from course material or from the teacher or the tutor. It is even claimed that the most powerful and sustainable learning process occurs among peers who pull each other rather than being pushed by experts. This way, collaborative learning is a creative process of articulating ideas, having them criticized or expanded, and getting the chance to reshape them or abandon them, all in the light of peer-discussion (Rowntree 1995).

Collaborative learning can be understood in terms of distributed cognition, which is about sharing information and building knowledge. It implies collaboration as people are interacting and learning together using technology (Roschelle and Teasley 1995), but also collectiveness, when people are succeeding in building a shared representation and to some extent shared cognitive system (Dillenbourg, Baker et al. 1996). Distributed cognition extends beyond an individual's mental activity to include everything in that individual's environment; it comprises the individual, peers and tools. Hence, it is the interaction among these that ensure individual as well as collective knowledge building. This compared to 'cognition' which is something residing in an individual.

Distributed cognition has also been discussed in the context of organizational learning (Boland, Tenkasi et al. 1996). Here, distributed cognition refers to the process whereby individuals who act autonomously within a decision making domain make interpretations of their situation and exchange information with others with whom they have interdependencies so that each may act with an understanding of their own situation and that of others. Information technology can support distributed cognition by enabling individuals to make rich representations of their understanding, reflect upon those representations, engage in dialogue about them with others, and use them to inform action. The context for the learning is also emphasized in notions such as situated learning and situated cognition where it is emphasized that all knowledge is situated in the environment where it was acquired (Suchman 1987).

When students and educators are engaged in collaboration, the teaching and learning process becomes different than in traditional teaching. The students, rather than being passive recipients of information,

have to be active and engaged cognitively and articulate, explain and criticize. The educator, rather than being the 'sage on the stage,' has to release the process of learning and knowledge building to the students and in the students. However, the responsibility of creating a good atmosphere and making learning possible still resides very much with the educator (see for instance (Laurillard 1993) or (Ramsden 1992)). However, collaboration is not simply a treatment, which has positive effects on all participants. Collaboration is a social structure in which two or more people interact with each other, and according to Dillenbourg (Dillenbourg, Baker et al. 1996) under some circumstances, some types of interaction have a positive effect.

In making learning possible, information technology is suggested to be a powerful tool (Pea 1993). It is claimed that computers can *"facilitate the development of knowledge building communities"* (Scardamalia and Bereiter 1994). The importance of understanding the underlying pedagogical assumptions when designing IT for educational purposes is emphasized by for instance Leidner and Jarvenpaa (Leidner and Jarvenpaa 1995). In this paper, we will use the established concept of asynchronous learning networks (ALN) when referring to information technology based environments supporting teaching and learning. ALNs are built using different tools for computer mediated communication (CMC). Examples are email, bulletin boards and newsgroups, synchronous chat systems, computer conference systems, group decision support systems, and most recently, the World Wide Web (WWW) (Hiltz and Wellman 1997). In an ALN, learners form a community where they are engaged in collaborative learning at the time and place of the individual learner's convenience (Bourne, McMaster et al. 1997). By slowing down interaction, learners are given time for reflection, and ideas, questions, comments, etc., can grow and mature before being shared with other learners.

Learning processes and the role of educators and learners in ALNs are radically different from traditional classrooms (Harasim, Hiltz et al. 1995). An important issue to remember is that ALN based learning is a social process, since *"though the classroom is virtual, the relationships and the learning it supports are real"* (Hiltz and Wellman 1997). In a virtual learning environment, such as an ALN, building on the notion of

collaborative learning, examination in the traditional sense becomes problematic as discussed in the next section.

2.2. Assessment and Examination

Whereas assessment of learning and examination of different types are used throughout the education system, there are many competing, and sometimes conflicting, understandings of the meaning and purpose of assessment and examination. It is even claimed that assessment of students often is a tragic enterprise (Ramsden 1992). In this section we discuss some of the different understandings more in detail, and propose an understanding of assessment and examination viable in a virtual learning environment.

Kvale suggests that there are three main functions of examinations (Kvale 1975): recruitment, pedagogics and power. First, he suggests, it is a system of recruitment through controlling the access to studies and other positions. Candidates who have passed an examination are given access to privileges from which those who have not passed are excluded. Second, examination has a pedagogical function as it is steering the learning process. What is evaluated in the examination and how it is evaluated will influence the acquisition of knowledge and the development of thinking. Third, when the examination functions as a means of controlling the recruitment and influencing the learning process, it is a power function. Through such a system recruitment as well as thinking is controlled.

Further, assessment may have any of three major goals, according to Rowntree (Rowntree 1977): to assign a rating or a grade, i.e., summative assessment, to give feedback to guide or improve behavior or practice, i.e., formative assessment, or to compare the effectiveness of alternative elements of a course or curriculum, i.e., comparative assessment. It can of course be an integration of all of these three goals. In his discussion, Rowntree concludes that assessment is about getting to know our students and the quality of their learning.

Assessment is relativistic as it is about several things at once according to Ramsden (Ramsden 1992). Assessment …

> ***"… is about reporting on students' achievements and about teaching them better through expressing to them more clearly the goals of our curricula. It is about measuring student learning and it is about diagnosing specific misunderstandings in order to help students learn more effectively. It concerns the quality of teaching as well as the quality of learning: it involves us in***

learning from our students' experiences, and it is about changing ourselves as well as our students. It is not only about what a student can do; it is also about what it means he or she can do" (ibid. p.182).

If we understand assessment fundamentally as helping students to learn and for educators to learn about how best to teach them, in other words formative assessment, we also know that learners often require extra support to engage in unfamiliar tasks. Students are a diverse population, varying in knowledge, skills, interests, and learning styles. Thus, one understanding of formative assessment is scaffolding. Therefore, the needs of learners suggest the use of scaffolding to improve the learning process. Scaffolding refers to the support provided so that learners can engage in activities that would otherwise be beyond their abilities. Jackson et.al. (Jackson, Krajcik et al. 1998) defines scaffolding as covering the following three categories: supportive, reflective and intrinsic. First, supportive scaffolding which is support for doing a specific task. It is provided alongside the task to offer advice and support. Second, reflective scaffolding which is support for thinking about the task. It is not changing the task itself, but makes the activity of reflection explicit by eliciting articulation from the learner. Third, intrinsic scaffolding is the support that changes the task itself by reducing the complexity of the task and focusing the learner's attention.

Formative assessment and summative assessment have also been discussed in other terms as there continues to be a raging debate over the relationship between assistance and assessment. In this debate, it is generally agreed that assistance promotes learning, growth and development. Rather than measuring the minimum competencies, assistance starts with where the learner is, and then designs plans for promoting acquisition and development of new skills. In contrast, assessment implies quality control, providing educators with means for deciding whether the learner has acquired the minimum level of knowledge. However, grading and categorizing should not, as many people seem to think, be viewed as a 'bad thing' (Ramsden 1992). Others have argued that assistance and assessment can not be carried out simultaneously (Popham 1988), but have to be separated (Reiman and Thies-Sprinthall 1998). This implies that educators face a dilemma, as they are many times responsible for both helping students to learn, but also

responsible for grading the students. In other words, examination is a problematic task for many educators.

In this research, assessment is regarded, not as an addition to teaching, but an integrated part of teaching and learning. Therefore it is suggested that the appropriate approach for conducting examination in a virtual learning environment should mainly be of formative character and the possibility of anytime/anywhere learning (and teaching) makes it possible to separate the responsibilities to a great extent. For instance, the course coordinator can be responsible for the summative part and teaching assistants can be responsible for the formative part. However, even if being convinced that a formative approach is the most appropriate in the virtual learning environment, there are many situations where the educator is confronted with the formative/summative (or assistance/assessment) dilemma as discussed above.

With collaborative learning and a formative understanding of assessment, a three-phase research approach which is investigating assessment and examination is outlined below.

3. Research approach

Examination can be studied from a number of perspectives. With the research goal of informing the design of computer support for collaborative learning and formative assessment, a three-phase research approach was defined. The first phase is studying a part of the world and gathering data. The second phase is design of computer artifacts informed by the first phase. The third phase is an evaluation of the artifacts designed in the second phase.

The overall research approach is *phenomenological*, as it is claimed to be important to understand how examination is perceived by students in order to find and implement alternative forms of examination. In phenomenology the researcher is committed to understand phenomena from the individual's own perspective. The researcher examines how a part of the world is experienced. In this way, the important reality is what people perceive it to be. The research is *applied research* since the aim of the research is to contribute to the knowledge about the nature of examination. In addition, it is also *action research* since the purpose is to experiment through intervention and to reflect on the effects of the intervention as well as on the theoretical foundations. Action research can

address complex problems and the immediate concerns of, in this case, educational practice.

Statistical analysis and content analysis as well as design were applied as methodology in this research. This way the research is methodology triangulation (Denzin 1978). The logic of triangulation is based on the premise that …

> ***"… no single method ever adequately solves the problem of rival causal factors …. Because each method reveals different aspects of empirical reality, multiple methods of observation must be employed. This is termed triangulation. I now offer a methodological rule that multiple methods should be used in every investigation" (ibid.).***

The purpose is to study a part of reality with the aim of identifying areas where information technology can provide a substantial and sustainable change and improvement. In the following, the three phases of the research are described more in detail.

3.1. Phase One - Survey

Over 700 business students at a Business School of a Swedish University were approached with a survey during exam week at the end of the spring semester 1998. A total of 438 surveys were returned and of these, 371 surveys were complete and used in the analysis. In other words approximately 50 percent of the surveys. The students were anonymous and answered a series of questions about their perception of examination. Both Likert-scale based questions and open-ended questions were used. Statistical analysis was conducted and the result as well as descriptive statistics are summarized below. It should be noted that an extensive analysis and discussion of the statistical results describing the sample student population are beyond the scope of this paper. The motivation for using this sample was mainly to get a large material, and from several departments of the Business School. There were limited resources at the time of the data collection, which excluded other data collection approaches such as interviews.

The distribution of the 371 students' departmental affiliation were the following: 30 percent (112) of them were majors in *commercial law*, also 30 percent were majors in *Informatics*, 24 percent (90) were majors in *business administration* (BA), and the remainder, 16 percent (57) of the students, were majors in other areas such as *economics* and *cultural geography*. These four groups, BA, LAW, Informatics and others, were

used in the analysis of the material. There were 192 women and 179 men, between 19 and 49 years old, and with a mean age of 24 years (sd 4.5). The number of semesters in higher education, including the current semester, varied between 1 and 12, with a mean of 4.9 semesters (sd 2.6).

The students were initially asked to rate their own level of ambition. 27 percent of the students considered themselves as very ambitious, 57 percent as ambitious, and the remainder, 16 percent, did spend as little time as necessary on their studies. The students were asked to rate how they perceived different forms of examination in a five point Likert scale ranging from 1 (negative) to 5 (positive). Table 1 below summarizes their responses.

Type of exam	Short description	Mean	Std
Written exam	2 to 5 hour written exam covering specific literature or a well-defined topic.	3.6	1.1
Home assignment	From 1 day to one week for working with essay-like questions at the time and place of the choice of the student.	3.5	1.1
Longer essay	From 1 week to 1 month for researching a topic and reporting it in a formal report.	3.5	1.0
Short paper	1 week for researching a topic and reporting it in a short report.	3.5	1.0
Group assignment	Dyads or larger group work for 3 days or longer with a specific task.	3.3	1.1
Seminar	Student or teacher led meeting with 2 or more students and one or many teachers. Issues covered in the course are discussed.	3.2	1.1
Verbal exam	Meeting with one student and one teacher. Informal discussion about the issues covered in the course.	2.6	1.2

Table 1: Perception of examination

Thus, the table above shows little variation between the perceptions of the different types of examination; but turning to preferences divided by the four groups (BA, Law, Informatics and others) as discussed above, there are some interesting differences. Activities where groups were examined for the joint work was rated very high (4.4) by Informatics students, whereas business administration majors rated written exam almost as high (4.0). Verbal examination is not very common, very few students had experienced it, still many students would like to try it. The students were then asked which form of examination they preferred. They could only choose one of the seven forms. Table 2 summarizes the responses.

Type of exam	BA	Law	Inform.	Others	Total
Written exam	53	45	16	27	141
Group assignment	11	7	60	8	86
Home assignment	9	28	16	12	65
Longer essay	0	17	7	3	27
Seminar	5	9	9	3	26
Short paper	9	3	0	3	15
Verbal exam	3	5	2	1	11

Table 2: Preference for examination form

The preference for examination varied among the four groups. That 141 students, almost 40 percent, preferred the traditional written exam was a bit surprising. Studying the table above it is suggested that Business Administration and Law students have a strong preference for written and individual exams, whereas Informatics students prefer group assignments. This was expected, as written exams are most common in both the departments of Law and BA. Similarly, at the department of Informatics, group assignments are the most common forms of examination. Students tend to prefer the examination form they are used to and familiar with. The relationship between the departmental groups and preferred examination form was significant (chi-square 196.7, p-value > 0.0001). Other relationships were also tested. We found that

women are significantly more nervous than men when it comes to examinations as 71 percent of the women admitted being nervous, but only 29 percent of the men (chi-square 66.3, p-value > 0.0001). Women prepare for exams differently than men as they claim they start earlier with their preparation. Moreover, women seem to prefer examination forms that are based on individual achievements rather than group performance. However, as these findings have limited implication for the purpose of this research they are not reported here at any length.

The question of what form of examination they preferred was followed by an open-ended question where they were asked to motivate their answer. The answers to the open-ended question were analyzed through interpretative content analysis (Patton 1990). The students' motivations for preferring one type of examination was coded and categorized. Three categories stood out clearly: Learning, fairness and convenience. Let us look into each of them more in detail. All quotes in this section are taken from the survey.

First, in their motivation of why preferring one form of examination, almost fifty percent of the students gave learning as a motivation. That is, the preferred form of examination was perceived as a learning activity, or an opportunity to learn. For written exams, this was for example motivated as *"I have time to prepare and acquire knowledge in the way I learn best,"* and for short essays, *"it is independent, realistic and it is knowledge that really stays."* For group assignments, an example is that *"it is stimulating, and the learning process is really efficient as the problems are discussed in the group."*

As a second category, fairness and equal treatment was given as motive for a preferred form of examination by approximately one fourth of the students (mainly BA and Law students). For written exams, one student wrote *"it has to be difficult, otherwise everybody will pass, and with very little effort."* For short papers and longer essays it was motivated as *"it shows what the individual student really knows in a realistic and fair way."* Fairness and equal treatment was not stated as motivation by any of the students who preferred examination forms involving groups.

The third motivation category, also chosen by one fourth of the students, to why they preferred one form of examination was convenience. Note that this does not mean convenient in the 'getting a good grade easy' way. Rather, a student preferring the written exam stated that, *"written*

exams, as they are over in a few hours, and I can easily fit that into the rest of my life." And as a student who preferred group assignments motivated her answer, "*I find the informal discussions and problem solving to be very efficient and practical.*" But also students who find home assignment to be the preferred form of examination, since "*I can work in my own pace, and where ever I want.*"

To summarize, the findings from the first phase, in relation to the overall aim of the research discussed in this paper, are the following: The survey showed a very diverse perception of examination among the students. We found that the preferred form of examination was strongly related to what the student was majoring in. Gender did also influence how they related to examination. Further, the motivation to why a form of examination was preferred was categorized in three distinct categories: it is an opportunity to learn, it is fair and it guarantees equal treatment, and it is convenient. In addition to these three categories, we also found that the students would like more dialogue and feedback in general in the learning process, and especially in the different examination activities.

It is clear that a 'one size fits all' approach is likely to fail. Instead, educators should use a portfolio approach in conducting examination. With these findings, the second phase was initiated.

3.2. Phase Two - Design

In the second phase, two forms of computer supported examinations were designed according to the findings in the previous phase. The first, Mandatory Participation as Examination (MPE) was implemented through configuration of a commercially available web-based computer conference system. In the second, Peer reviewed Report (PeeR) a web-based application was designed and developed to facilitate peer review of short reports and essays.

3.2.1. Mandatory Participation as Examination - MPE

Net based learning environments offer possibilities unavailable in traditional classrooms and one possibility is to make active participation a realistic criterion for examination. A, perhaps controversial, distinction between participation and presence highlights some of the weaknesses of traditional classrooms and strengths of asynchronous learning networks (ALN). To be present is simply to passively attend group sessions, but to participate is to contribute actively to group sessions.

Courses using ALNs are well suited for active participation in learning activities since learning can take place at the time and place of choice. An alignment of learning philosophy and examination, thus making examination an integrated part of the learning process, is suggested. Mandatory participation in an ALN supported learning activity offers integration between examination and learning, which is in line with the belief that it is not possible to separate the two. In most cases participation in ALN based discussions is optional and examination consists of assignments such as written exams or essays at certain times. Hence, demanding active participation is a debatable and radical move.

Participation and presence in educational activities is more than an issue of control; it is also an issue of equality. Learners who try to participate actively can be restricted by a number of social factors (Wegerif 1998). Whereas in traditional classrooms, learners must be allowed into the discussion before speaking, in an ALN, learners are part of the discussion at all times and there is no slow turn-taking. Compare this to 'real-time' discussions, where time is limited and many learners have difficulties in formulating and articulating contributions to a discussion under time pressure. In ALN based discussions, ideas can grow over a longer period considering that contributions are situated in a multi-topic discourse. Thereby, the moment where the contribution is suitable is extended over time. In traditional classrooms discussions change direction rapidly and the 'right' moments to contribute to the discussion are momentary.

Mandatory participation is a continuous form of examination where learners must be 'reasonably' active throughout the course. To determine when a person is reasonably active is of course not trivial. This is further discussed in the evaluation of MPE in a later section. Therefore, learning activities should be (evenly) spread over the duration of the course. This way learners can choose to be more active during some period and less active in another. Examination outcome is determined by the total participation, not, as in most traditional educational settings, by large assignments at certain times, usually at the end of the course. In order to achieve this flexibility in participation the course can for instance be structured as thematic modules (TM).

Thematic modules is a structuring philosophy which divides the course into several self-contained uniformly structured units (Nuldén 1999). This

is different from traditional modular structuring where a large topic area is divided into subtopics small enough to digest for learners (like chapters in a book). In TM, each module introduces a separate issue or problem, like tiny islands in a vast ocean of knowledge. The *construction* of 'bridges' between the islands is done through facilitated collaborative activities. Every module has a well-defined beginning and ending. Because each module is self-contained, learners can be more or less active in different modules according to interest and outer circumstances, as long as the total participation is 'satisfactory.'

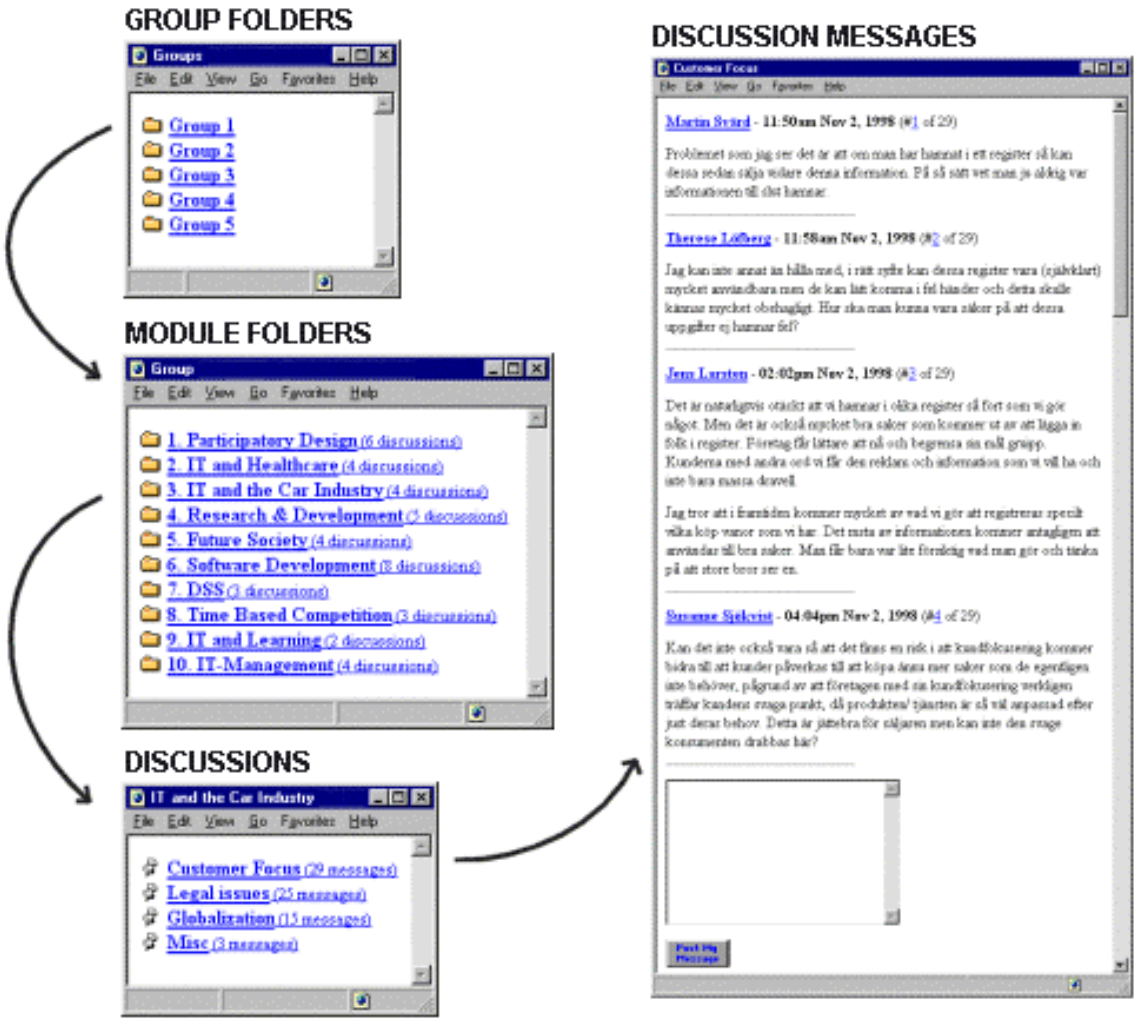

Figure 1. The ALN for MPE

The ALN used for MPE should be highly structured and hierarchical. Figure 1 shows screenshots of a possible ALN interface. Each group has a separate area, i.e. group folder, and within the folder there are, in this case,

10 folders, one for each module. During a module, the group would create appropriate discussions in the current module folder. Discussions are areas for individual messages and, as shown in the figure above, new messages are appended to the sequence of previously posted messages. In MPE, the ALN should be structured but this is not a requirement for thematic modules in general. How MPE was applied and evaluated in a course is described in the evaluation section. In the next section, the second form of computer based examination is described.

3.2.2. Peer review of Reports - PeeR

Whereas activities building on the notion of collaborative learning can take many forms in practice, peer review is one possible way to engage learners in collaborative activities. Peer review of, for example written reports, is also of formative nature as the purpose is to suggest how to improve the reports. The value of peer review in higher education is widely recognized by educators and educational researchers. For instance, it is claimed that *"students are found to plan more extensively and write more carefully when they are communicating with an audience of peers than when they are being evaluated solely by the instructor"* (Bagley and Hunter 1992). Similarly, *"it's worth emphasizing that it is not always necessary for academic staff to give feedback: students can often learn more from formal or informal assessment by their peers or by themselves"* (Ramsden 1992). Peer review includes many qualities from a learning perspective, such as articulation of understandings and horizontal interaction among learners. In the research community peer review is the most widely used approach when evaluating research.

However, focusing on higher education practice, peer review in large classes is by default problematic since it creates an, in many ways, unbearable administrative burden on the educator coordinating the peer review process. Imagine administrating one or two hundred students writing papers and reviewing each other's papers within the current course budget.

Networked environments can be a solution to overcome, at least, some of these problems. The value of peer review in an online environment has been suggested by for instance Harasim et.al. (Harasim, Hiltz et al. 1995). They suggest that students can work together in dyads or in small groups, using email or computer conferencing, for example for the first draft of

their course paper. The instructor, they continue, provides a framework to guide peer critiques, and the grading assesses both the quality of the draft and the quality of the critique. In this research, these ideas are taken a little further and a web-based application for conducting peer review in large classes is suggested. PeeR (Peer review of Reports) is an application designed for publishing, reading and commenting on short reports via the WWW.

Below the functionality of PeeR is described. Students write shorter reports or essays (2-4 pages), or longer reports following the specific instructions from the course coordinator, and submit those to PeeR in the web-form as shown in the figure below.

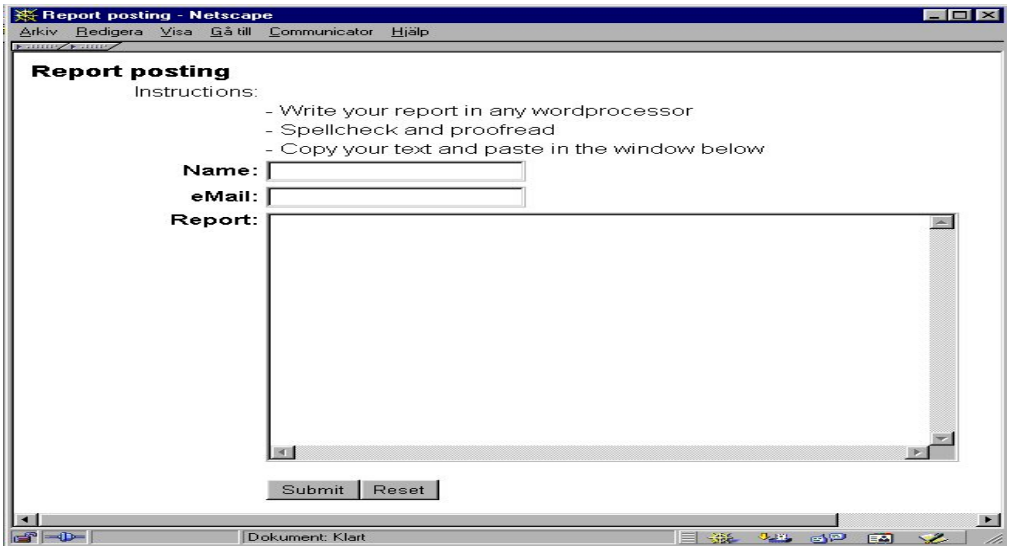

Figure 2: Report posting

The reports are published in PeeR where all students participating in a course have access to all reports. The level of access is under control of the course coordinator. Each student is assigned one or more reports to review and the PeeR application can be configured to email the student with the result.

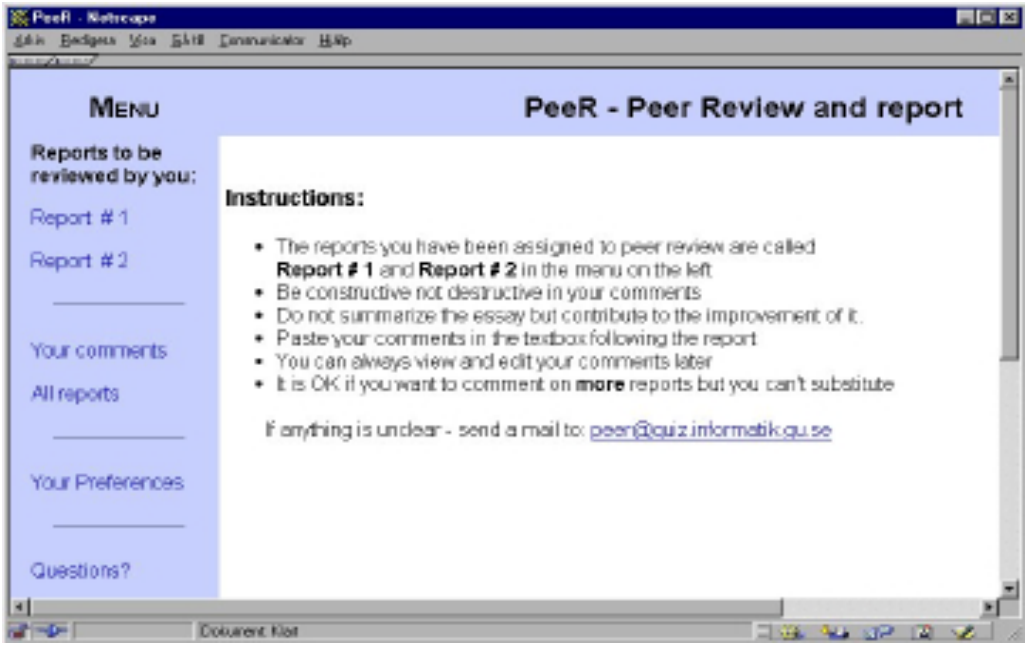

Figure 3: Peer Review

Basically, as in all peer review, the students read, reflect and make constructive comments on their assigned reports (and optionally on any of the other reports). Deadlines for accepting postings of reports and comments may be preset in the application or changed at any time. Both reports and comments are stored in the PeeR database for easy retrieval and presentation in any format. After the review process, the teacher assesses both the report and the comments made by each student. The teacher provides feedback to the students on both report and on the reviews. This way it is possible for both authors and reviewers to reconsider what they have written, and revise their writings. The grade a student receives is dependent equally on the report and on the quality of their comments to others. Other combinations for grading can also be applied. PeeR was designed and developed on a standard PC with Internet Information Server (IIS) and Microsoft Access. As with most web applications, PeeR is available regardless of time and place, and it is platform independent for the user. PeeR will later be included as a module in a web-based learning environment currently being developed.

3.3. Phase Three – Evaluation

The ideas of MPE and PeeR were used to design the course 'Introduction to Informatics for Business Administration (BA) undergraduates.' The aim of the course was to introduce the students to the field of informatics by

showing and discussing how information technology is applied in a variety of fields. The course was also used to evaluate the two ideas. The motive for evaluating the ideas in this course was partly practical since the course was given at the time of the research. Another reason was the fact that BA students, according to the findings in phase one and shown in table 2, seemed to have very strong preferences for written exams as well as individual focus and were therefore appropriate for testing alternative examination forms. A total of 85 students participated in the course.

3.3.1. Evaluating Mandatory Participation as Examination - MPE

The main portion of the course was designed based on mandatory participation and TM. Each module was initialized with a two hour lecture. The rest of the week-long module consisted of ALN based discussion in groups. An end-of-module summary by the students in each group provided closure of the module. The course lasted 10 weeks, which was covering 10 modules, and awarded two credit points. The 85 students were divided into five groups, each having a teaching assistant (TA) to facilitate and support online discussions. Before the course started, the course coordinator and the TAs participated in a half-day workshop to discuss the role of the TA. One of the TAs' many important responsibilities were to inform the course coordinator about students who were not fulfilling examination requirements, that is, participation. The course coordinator would then judge the student's effort and take full responsibility for any final decision to fail the student. Deciding if a student's participation fulfilled the examination requirements was in some cases difficult. Some limited tools, i.e. visualization of discussions, were available to make it easier to understand each individual's level of participation but these tools were very much in their infancy. The issue of technology support for visualizing and facilitating discussion is however beyond the scope of this paper but is an important area for future research.

Half-way through the course the coordinator and the TAs thoroughly discussed the students' participation and five students were judged to be non-participant and as an effect of being failed they were no longer allowed to access the ALN. For the second half of the course none of the remaining students neglected participation so they all passed the MPE part of the examination. Having passed the primary examination, they were allowed

to complete the end-of-course assignment (PeeR), determining the final grade for the course. This is described later in the paper.

To evaluate how the students perceived MPE a survey was conducted one week after the course was completed. There were a total of 61 students, 31 men and 30 women between 20 and 38 years old, and with a mean age of 23 years (sd 4.9) who answered the questions. Figure 4 below shows the distribution of the answers to the questions, (1) if the students found MPE to be a form of examination that was an opportunity to learn, (2) if it was a fair way to conduct examination, and (3) if this form of examination was convenient. The answers were in a six point Likert scale ranging from 1 (negative) to 6 (positive).

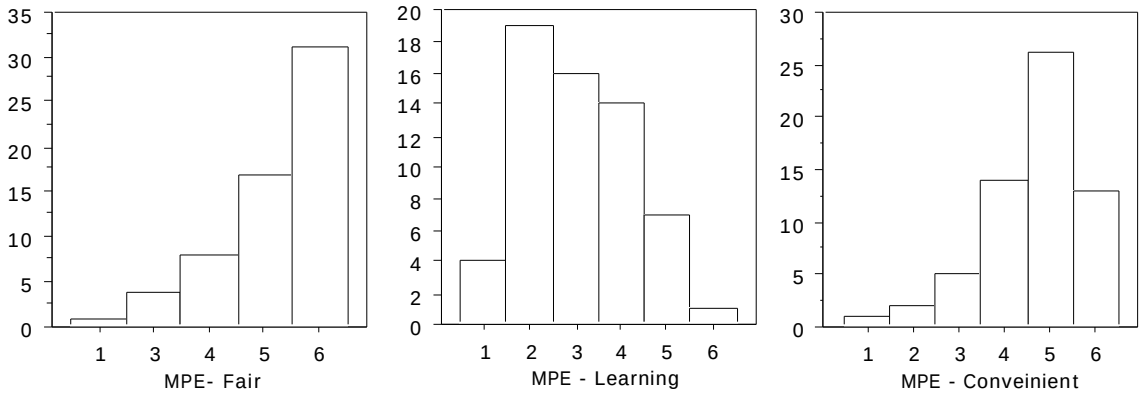

Figure 4: Students perception of MPE

Mandatory participation as primary examination criterion was appreciated by the students according to the rating of the fair and the convenient aspects of MPE, but the low rated learning is problematic. However, one interpretation is that discussing with other students is not perceived as learning for students deeply rooted in a teacher-centered view of education. Further research is needed to identify viable ways to introduce this form of horizontal learning activities, since this is a very different way to think about education, and learning, for many individuals.

There were some problems in accessing computers, causing, as expected, a conflict with the mandatory participation demand, but only a few students faced this problem and they managed all right despite this disadvantage. Many students wanted us to reserve computers in the labs for them regularly but as this is in conflict with the notion of anywhere/anytime learning, it was not done. It should be noted that the

students were judged tolerantly, only apparent cases of low participation were failed. This does not mean students passed for free; determining reasonable participation is difficult as discussed above, we decided to pass rather than fail the uncertain cases.

Below, we will also share some of our experiences, or anecdotes if you wish, from the course which are related to mandatory participation. The experiences serve to give some depth in the understanding of problems and difficulties involved in ALN based learning and mandatory participation.

New and Different

The ALN based course was in sharp contrast with previous courses the students had experienced. The shift from teacher-centered to learner-centered education was somewhat of a revolution to many. The learning ideas were new and the students were not used to unstructured tasks, open-ended discussions with no true answer, and the notion of creating knowledge for themselves rather than producing it for the teacher. They were hampered by a textbook focus and lack of initiatives. Roughly some of the students were asking: *"What are the exact examination criteria and when is the final written exam?"* The students were given a brief manual for the ALN, a short demonstration, and an optional half-day workshop. The few computer novices learned quickly and some of them remarked afterwards *"oh, was it that simple..."* Many of the lecturers, especially those who were professional teachers, were also stuck in the traditional view on learning. Their lectures were not perceived by the students to serve as a starting point. To view a lecture as a starting point for a discussion instead of as an overview or summary is a difficult change process. People from industry were more successful than teachers in giving lectures as starting points for discussion. For the course coordinator and TAs it was also a new and challenging situation. We had little previous experience of this form of collaborative learning and knew it would be a difficult process, for us and for students. Therefore, it was necessary to have a positive attitude by, for example, having extended office hours. Introducing the ideas to the students and fellow teachers was not trivial.

Off-topic discussions

Two examples of what we call off-topic discussions were apparent. The first example concerns non-serious discussion, i.e. topics not related to the course. The second example concerns students posting to serious

discussions but with the intent to pass examination, not contributing to the learning process. Examples of non-serious discussions were sports discussions, TV-show discussions, and music discussions. Each of the five groups created about two such discussions and, unlike the serious discussions, these lasted throughout the course. These discussions were popular judging by the volume of messages they received, for instance one discussion about ice hockey consisted of 140 messages. The tone of voice was different, more relaxed compared to serious discussions. The decision was made that non-serious discussions should be kept totally separate from serious ones, not so much where they are placed, but more importantly avoiding interfering issues. The second type of off-topic discussions concerned students feeling the pressure to post something in order to pass the examination. Talking to students at office hours, many of them dared to admit posting not to contribute to discussions but to meet examination criteria; they posted just for the sake of it. Some joked about the need to say something serious quickly in the beginning of the module before everything was said. Especially during the first modules students tended to post similar messages, rather than building on each other's contributions. Another reason for low-quality messages were the problems in accessing computers. The affected students simply had to do everything at once when they found a computer, that is read, think, and post. There was no room for reflection since leaving the computer and coming back later to post was unthinkable.

Maturing

During the course the students changed attitudes, learning strategies, etc. At first many students had difficulties seeing the point of collaborative learning but over time some students revised their attitude to this way of learning and realized that one can learn from interaction with other learners. Of course, not all students were convinced and 10 weeks is a short time to change one's perception of what learning is. We do however believe that the experience has started a thinking process within most of the participating students. In addition, students at first had trouble with the mandatory participation criteria. As one of the teaching assistants expressed it: *"Initially my students thought mandatory participation meant they had to be constantly present in the ALN. This caused frustration and they said 'Be there all the time? This can't be? We have*

other things to do!'. Gradually they realized what we meant and eventually they started working as intended with about one visit per day to update themselves, reflect, and post messages."

Frustration

One of the TAs' responsibilities was to stimulate students who were inactive and not participating in a satisfactory manner. The first difficulty was to decide when a student was not reasonably active. All TAs had different personal styles but none wanted to appear bossy or bad tempered, so pushing students was difficult, especially when faced with a borderline case of inactivity. This gives us the second difficulty, namely how to approach students and give them a friendly push. Another practical issue is being able to contact students. Sometimes reaching inactive students was impossible because they did not participate in the discussions and we did not have their email address nor their telephone number. In some cases a TA felt that she or he was saying something really interesting and challenging, only to be disappointed when no reaction was triggered. Either the students were not interested in the new discussion option or they simply lacked the experience to build on feedback that was too advanced. Providing fruitful feedback is a very complex issue and it is further complicated by the fact that students have quite different backgrounds, experiences, and preferences.

Summing up, our experience shows that the alignment between learning and examination was not complete since many students adopted strategies purely focused on passing examination. This was our first evaluation of mandatory participation as examination so of course further research is needed. A multitude of issues need to be explored further, such as facilitating learning processes, technology support for TAs, other ALN based examination forms, and how to further integrate learning and examination.

3.3.2. Evaluating Peer Review of Reports - PeeR

PeeR was evaluated in the same course as 'mandatory participation as examination' (MPE) as discussed above. The students who had passed MPE were required to write a short report and review two others as an examination determining their final grade at the end of the course. The ideas involving PeeR is by no means new, but with the computer based application, performing peer review with larger classes becomes a

complement to other forms of examination. We wanted the topic of the report to reflect the discussion in the course and involve both issues of interest to the students and within the realm of the objective of the course. Therefore, the topic was decided only a few days before it was presented to the students. Thorough information about what was expected of the students was provided both in class and on the web—instructions for how to write the report but mainly for how to perform peer reviews and how to use PeeR.

A central aim was to have the students view the report and the peer review as non-separable activities of the examination. Figure 5 shows the distribution of the answers if the students found PeeR to be a form of examination that was an opportunity to learn, if it was a fair way to conduct examination, and if this form of examination was convenient. Again a Likert scale ranging from 1 (negative) – 6 (positive) was used. As figure 5 shows, the students rated all three criteria high. The students seem to think that PeeR has a large potential in being a viable form of examination.

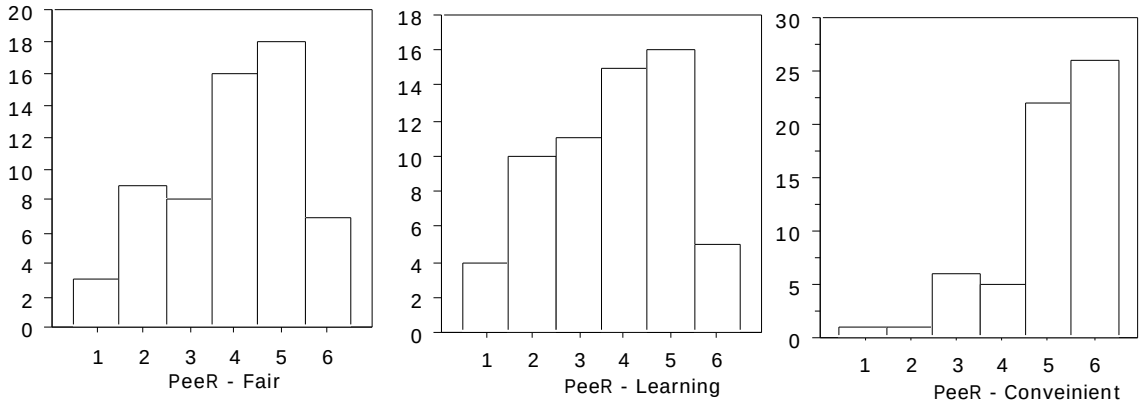

Figure 5: Students perception of PeeR

From the perspective of the course coordinator, it was clear that the open assignment of writing the report invited the students to relatively freely structure their report. Hence, from a qualitative perspective most of the reports did not meet academic standards. More connection to the material and issues covered in the course was however expected despite the fact that this was not emphasized in the instructions. Apparently, many students experienced difficulties in being constructive when commenting on their peers' writings. And, as we all know, "*making criticisms is ten times easier*

***than coming up with a constructive alternative*" (Nonaka 1995). Limited instructions in the form of guidelines were provided. Still the difficulties in being constructive were apparent. However, very few destructive comments were made. Summarizing, the report and the peer reviews, the overall student achievement must be considered as meeting the quality expected of second year business students.**

Due to rather extensive online help, assistance from the administrator was practically nonexistent during the report posting stage. It was more a question of giving more information about the requirements for the report. In the review stage, however, the administrator played a more active role. The major reason for this was PeeR's use of *cookies* (information about web-sessions stored on the users' computers) and the fact that a great deal of the students had disabled them in their web-browsers. In addition to this, the campus computers, administered by the computer department at the Business School, did not allow the students to accept any cookies. This was a matter of misconfiguration and once identified it was easily solved. These problems are neither new nor especially surprising—it is common in a distributed, platform independent, heterogeneous environment—but it is nonetheless a problem.

The main findings of using PeeR in the course and the evaluation can be summarized as follows: First, the survey of the students showed, as we interpret it, that our use of PeeR was successful. The participating students found PeeR to support learning in addition to being a fair and convenient form of examination. Second, from the perspective of the course coordinator, as stated above, peer review was a new form of examination to most of the students. However, by a more thorough discussion with the students about the purpose of peer review as examination, as well as more structured instructions and guidelines, PeeR is believed to be a viable complement to other forms of examination in large undergraduate courses. And third, we find that peer review is possible to administrate even when the number of students is substantial, albeit there is still much work to be done with the application.

Informed by these findings we outline the following further development of PeeR: the design and development of the full application with an administrative interface and a larger number of settings controlled by the course coordinator; to give the option of converting essays to portable document format (pdf), in order to enable the application to

email large documents to the reviewers; to have the comments instantly mailed to the author of the essay to give them the possibility to follow the progress.

4. Conclusions and Implications

The major reason for doing research in education is to develop new knowledge about teaching, learning, development and administration. Moreover, the new knowledge should of course, (immediately or at least eventually) lead to improvement in educational practice. The ultimate value of educational research is determined by initial insight and creativity regarding the identification and selection of relevant and important research questions, but also the applicability to improve educational practice in some dimension.

Hence, in this paper, education in Business Schools is discussed in the light of collaborative learning, assessment, examination and information technology. This paper has claimed that it is well known that examinations have a control function, and may be argued to constitute part of a hidden curriculum in relation to a program or a course. The paper has discussed a change of the nature of teaching and learning by examining the relationship between assessment, examination and information technology.

The main conclusions in this paper are the following: First, there is a diverse perception of assessment and examination among the students. Gender and departmental affiliation are the most influencing factors when relating to different aspects of examination. Second, a combination of mandatory participation in an ALN-based discussion and peer review of reports is an efficient approach to assess learning and examine Business Students. However, introducing new educational activities such as different forms of collaborative learning involves extensive and careful planning to be successful. Assessment of learning and teaching, and examination of students combined with computing technology is an area in higher education where there is a need for more research.

There are needs for penetrating analyses of *how or why we do what we do* when we conduct an examination as this have been almost completely lacking in a systematic way. It is possible to increase the quality of higher education and better satisfy society's needs for a high level of expertise by developing the form and content of examination practice. Therefore, we

are currently interviewing business school faculty about their perception of assessment and examination. Approaching teachers to discuss examination was more difficult and to many teachers also a more controversial issue than expected. So far, our tentative insight is that examination for many educators seems to be a fairly un-reflected activity.

Acknowledgements: Thanks to Christian Hardless and Per Åsberg.

5. References

Bagley, C. and B. Hunter (1992). "Restructuring, Constructivism, and Technology: Forging a new Relationship." Educational Technology (July): 22-27.

Boland, R. J., R. V. Tenkasi, et al. (1996). Designing information technology to support distributed cognition. Cognition within and between organizations. J. R. Meindl, C. Stubbart and J. F. Porac. Eds. Thousand Oaks, CA, Sage.

Bourne, J. R., E. McMaster, et al. (1997). "Paradigms for On-Line Learning: A Case Study in the Design and Implementation of an Asynchronous Learning Networks (ALN) Course." Journal of Asynchronous Learning Networks 1(2): 38-56.

Dahlgren, L. O. and F. Marton (1978). "Students' conceptions of subject matter: an aspect of learning and teaching in higher education." Studies in Higher Education 3(1): 25-35.

Denzin, N. K. (1978). The research Act: A Theoretical Introduction to Sociological Methods. New Yory, McGraw-Hill.

Dillenbourg, P., M. Baker, et al. (1996). The evolution of research on collaborative learning. Learning in Humans and Machines. Towards an interdiciplinary learning science. P. Spada and H. Reimann: 189-211.

Harasim, L., R. Hiltz, et al. (1995). Learning Networks - A Field Guide to Teaching and Learning Online. Cambridge, The MIT Press.

Hiltz, S. R. and B. Wellman (1997). "Asynchronous Learning Networks as a Virtual Classroom." Communications of the ACM 40(9): 44-49.

Jackson, S. L., J. Krajcik, et al. (1998). The Design of Guided Learner-Adaptable Scaffolding in Interactive Learning Environments. CHI 98, Los Angeles, ACM Press.

Kvale, S. (1975). "Examinations: From Ritual Through Bureaucracy to Technology." Social Praxis 3(3-4): 187-206.

Laurillard, D. (1993). Rethinking University Teaching - A framework for the effective use of educational technology, Routledge.

Leidner, D. E. and S. L. Jarvenpaa (1995). "The Use of Information Technology to Enhance Management School Education: A theoretical View." MIS Quartely 19(3): 265-291.

Nonaka, I. (1995). The knowledge-creating company: how Japanese companies create the dynamics of innovation. New York, Oxford University.

Nuldén, U. (1999). "Thematic Modules in an Asynchronous Learning Network: A Scandinavian Perspective on the Design of Introductory Courses." To appear in Journal of Group Decision and Negotiation.

Patton, M. Q. (1990). Qualitative evaluation and research methods, SAGE Publications, Inc.

Pea, R. D. (1993). "The Collaborative Visualization Project." Communications of the ACM 36(5): 60-63.

Popham, W. J. (1988). "The dysfunctional marriage of formative and summative teacher evaluation." Journal of Personnel Evaluation in Education 1(3): 269-273.

Ramsden, P. (1992). Learning to Teach in Higher Education. London, Routledge.

Reiman, A. J. and L. Thies-Sprinthall (1998). Mentoring and Supervision for Teacher Development. New York, Longmen.

Roschelle, J. and S. D. Teasley (1995). The construction of shared knowledge in collaborative problem solving. Computer supported collaborative learning. C. O'Malley. Berlin, Springer-Verlag: 69-97.

Rowntree, D. (1977). Assessing students. London, Harper & Row.

Rowntree, D. (1995). "Teaching and learning online: a correspondence education for the 21st century?" British Journal of Educational Technology 26(3): 205-215.

Scardamalia, M. and C. Bereiter (1994). "Computer support for knowledge-building communities." Journal of the Learning Sciences 3(3).

Suchman, L. (1987). Plans and Situated Action. The problem of human-machine communication. Cambridge, Cambridge University Press.

Wegerif, R. (1998). "The Social Dimension of Asynchronous Learning Networks." Journal of Asynchronous Learning Networks 2(3): 34-49.

Sixth paper

The ExCon Project: Advocating Continuous Examination

Urban Nuldén

Abstract

In this paper it is claimed that traditional examination often is destructive to the process of learning. It does not matter how good intentions educators have, it is the way they examine students that will have the strongest impact on how the students learn. The goal of the ExCon project is intervention in traditional examination. The paper discusses an alternative model for understanding assessment and examination of students. Product assessment is questioned as an appropriate approach. Instead it is argued that educators should, to a larger extent, provide the student with questions and other types of feedback during the ongoing activity and use communication as an important element of the examination. For this purpose, a software prototype for a mobile computing device to support the educator was designed and developed. An evaluation of the prototype was performed and the paper ends with some thoughts on the viability of the prototype in supporting alternative assessment and examination.

1. Introduction

For many years, educators have tried to improve education with different technologies. The reason for using a specific technology varies, but it is not controversial to suggest that the main objective has been rationalization. Computing technology in education has been, and still is, a tool to rationalize teaching. Two approaches dominate: First, as a tool for the educator to distribute facts and information to passive students. Presentation software and recently the World Wide Web (WWW), offers an opportunity to present the lecture and course related information in an appealing format. Second, as an alternative to the teacher so the students can practice on their own. There is a growing number of educational software packages available. Most of them show strong similarities with Skinners behavioristic ideas about the teaching machine. These approaches will do little but speed up ineffective processes of teaching as they reflect an objectivistic model of learning

When a new technology comes along, it is automatically integrated in the rationalization paradigm. In this paper, as a contrast to rationalizing, the ExCon project suggests that mobile computing can help educators assess students in a different way. We have designed and developed a software package for a mobile computer, Newton (www.newton.apple.com). The objective with the software is to enable the educator to keep notes about students and groups with the purpose of communicating the notes back to the students as feedback.

Keeping notes about individual students performance and group projects is nothing new. Neither is keeping the records in an electronic format, e.g., a small database on the desktop computer. Of course, the limitation with conventional computers is apparent. They are not mobile enough to easily bring along to seminars, on the train etc. The ambitious teachers start out with a well designed database and high intentions. However, after some time the record about the individual student as well as the different groups is a dispersed mass of database entries, manual notes, and mental notes.

ExCon is a part of a larger effort to create a collaborative learning environment. Computing and communication technologies such as electronic mail, bulletin board services, computer conferencing systems, and the WWW are having a profound effect on education [1].

Asynchronous learning networks (ALN) is a means to create this feeling of a true group of people who are learning together [2]. A central factor in ALN is the capability for learners to learn anywhere and anytime and still be part of a community of learners.

Methodologically, the ExCon project is intervention with the premise that examination in higher education must focus more on process and less on product, and that this can be supported by mobile computing. The paper is organized as follows: First a short methodological discussion. This is followed by a two sections, one about learning, and one about examination. Mobile computing is then briefly characterized. The software prototype, Tracker, is then outlined and the initial evaluation is described. The paper concludes with a discussion.

2. Research Method

The natural choice of method in an intervention is action research. In action research the researcher takes an active role as an interventionist and uses her own experience. According to Patton [3], the purpose of action research is to solve a problem here and now. A key assumption is that people in a setting can solve problems by studying themselves. The standard for judging action research is the feelings related to the process among research participants and researchers about the solution generated. The viability of action research in education is recognized by Gibbs [4] who found that: "They were using research and research tools to intervene, often successfully, in their own courses. This is the kind of research which gets results" (p.27). Action research has two aims: to contribute to solving practical problems, and some specific research goal, such as the development of an approach, a method or a conceptual framework. Action research has been a major approach in Scandinavia, especially within participatory design (See for instance the special issue of Communications of the ACM (36:4) 1993).

The main objective with ExCon is intervention in examination in computing education. A second aim is to contribute to examples of good computing technology use in educational activities. That is, the integration of computing technology and a pedagogical idea that is easily communicated to other educators. The task of educating computing professionals is associated with a number of problems. Maybe the most delicate is the fact that the students, after graduating, will not only live in a

time of accelerating change. But they will certainly contribute to the change. An important issue in computing education, as well as in any type of education, is the choice of appropriate models to guide the activities of teaching and learning.

3. Assumptions About Learning

Research over the past ten years has established a distinction between surface learning and deep learning [5]. The distinction is basically one between rote learning and meaningful learning. In surface learning students memorize information to satisfy assessment criteria by reproduction. Whereas in deep learning, the intention is to relate previous knowledge to new, and to understand. It is obvious that students vary in their approach from context to context, and between different courses. Few students always take a surface approach, but most courses have students taking both approaches to some extent [4].

Three models of learning are commonly applied in this discussion, the objectivist model, the constructivist model and the cooperative model. The objectivistic model of learning is based on Skinner's stimulus-response theory. According to the theory, learning is an unreflective change in the behavioral disposition of an organism [6]. The goal of teaching is to facilitate the transfer of knowledge from an active expert to a passive learner. The lecture method of teaching embeds the pedagogical assumptions of the objectivist model as the purpose of teaching is to present as much of the right information as possible. It is a "learning by being told" model of instruction.

In the constructivist model, rather than being transmitted, knowledge is created by the learner. Individuals are assumed to learn better when they are forced to discover themselves rather than being instructed. It is also emphasized that it is only when learners are allowed to construct new meaning that the goals of constructivism are truly achieved [6]. The instructor is a mediator of the learning process and provides tools in a learning environment.

The cooperative model share many assumptions with the constructivist model of learning. Whereas the latter is focused on the individual learner, the cooperative assume that knowledge is created as it is shared among learners [7]. In this way it is the process of getting two or more learners to work together to learn. And the more that is shared

among them, the more is learned. Each learner is responsible for learning and helping others to learn. Of course, as in a constructivist model, the educator serve as a mediator and facilitator of the learning process. In this role the objective for teachers is to provide tools for the students so they can construct their own knowledge. Research suggests that students plan and write more thorough when they are cooperating with peers than when they are being evaluated only by an instructor.

Both constructivist and cooperative advocates non-criterion forms of assessing students [8]. It is also suggested that traditional competitive assessment strategies may disable learning as the learner may be motivated to withhold knowledge that otherwise would be shared with other learners [6]. My standpoint here is very clear, learning in higher education should be deep by definition. The constructive and the cooperative models of learning offer guidelines for how to organize educational activities. Research has shown that students tend to take a surface approach when the assessment system is perceived to demand, reward or tolerate memorization. But it is also suggested that it is possible to change the students approach to learning by changing the assessment system [4].

4. Assumptions About Examination

Examination is control. This is the dominating conception of examination. It is necessary to control if the students have learned what they are expected to. The instrument of choice is a written exam or a term paper. Preferably at the end of the course so the whole course can be examined. If the student pass the test, she is vaccinated and never have to take the course again. Understanding and analytical abilities are not really asked for in traditional examination. If so, the instructor would have problems in assessing the student. Both students and educator is more comfortable if answers can be considered as right or wrong.

From a control perspective, the outcome or a product of educational activities are assessed and graded. A single activity, or in best cases, the outcome of a number of activities make up the final grade after a course. Group activities are extra hard to assess, who did what? At group presentations, the teacher demands that all students in the group present their part of the work. The outcome is often a fragmented project where all

the participants in the group complete their part of the work with very little interaction with the other students.

Unfortunately the requirement of a written exam is the main interest for many students. A control perspective restricts students from engaging in deeper learning and understanding and instead pushes them toward memorizing ideas and facts. If applying a control conception of examination the students are forced into a grade oriented approach. Educators encourage critical thinking when they are teaching, but examine their students according to conformity in ideas and detailed knowledge about facts.

Dissatisfaction with current assessment approaches has led to an exploration of feasible alternatives. Assessment needs to be transformed from conventional multiple-choice and memorizing facts into radical visions that attempt to measure academic abilities more directly than the traditional assessments. As an alternative, process based examination is advocated. Authentic assessment is an alternative which has been used to crystallize the growing movement of providing learners with active opportunities to demonstrate their abilities under more natural and authentic circumstances. Examination is the most powerful tool teachers have to facilitate a good learning process. If we teach students what to learn, we stimulate the desire to pass the examination. If we learn how to learn, we stimulate the desire to inquire and to learn more, the knowledge will come automatically. Examination is no longer a discrete activity at the end of the course, but imbedded continuously throughout the course.

From this perspective, assessment is feedback. The educator is supporting the learning by commenting and criticizing the learning process. This way, examination is embedded as an integral and natural part of the course. It has also been suggested that continuous feedback gives a dimension of reality to the learning process [9]. Dynamic assessment approaches encourage learners to engage with concepts and go beyond the simple recalling of facts. If more active assessment challenges the learner, it also challenges the educator. It was easier grading multiple choice tests and essays about specific issues. It was even easier evaluating projects that were generally uniform in presentation. It is important to stress the importance of an assessment and examination system which guarantees, to the extent that it is possible, high quality graduates.

Practicing alternative assessment, the number of students in the course will naturally affect the quality of assessment. With twenty students whom the teacher meets regularly it is likely that the students and teacher develop a deeper professional relation [10]. However, with 100 students in a course, knowing each student enough to give them high quality feedback becomes if not impossible, then at least very difficult for most teachers. The question is then how can computing technology be used to support alternative assessment?

5. Mobile Computing

In the early 1990s the Personal Digital Assistant (PDA) was introduced—a small hand held computer, with instant working capability. It could be used with a pen while standing or walking and had an unprecedented variety of built in storage and communication capabilities. The first versions were not very useful as many of the central functions worked poorly. Most people regarded them as toys. The handwriting recognition software installed in the PDAs did not provide the user with a reliable interface. Getting the computer to interpret the hand written text was a tedious work. The performance of the programs required a great deal of patience of the user as even the smallest operation took what seemed to be forever. But now in the late 1990s, the technical limitations are overcome with the arrival of the latest versions.

New technology can make us view old problems and phenomena in new light. Mobile computers, and especially PDAs is an example of new technology that has successfully found its way into areas such as health care, military purposes and retail to mention a few. However, the applications in these areas are often an effort to standardize and computerize routine tasks. Only marginal change and improvement of the work is done, if any. But new technology is also a tool to implement changes. Computing technology obviously offers new ways of working and organizing [11]. At the same time, we can also see that the educational system is usually adopting a wait-and-see policy before new technology is integrated, and as mentioned earlier, it is often integrated into a rationalization paradigm.

6. Tracker

The ExCon project and Tracker is an attempt to use mobile computing and the WWW to implement some of the ideas in the model of alternative

assessment described in a previous section. Tracker is a data storing and transferring application designed and implemented in a Newton PDA. At the current prototype stage, Tracker is integrated with several other applications, both commercial and shareware. At the early stage of the design, paper prototypes were used to refine the ideas and identify the functionality as well as the interface of Tracker. Many ideas are still only in the paper version.

Designing Tracker, the starting point, together with the theoretical discussion, was the vision of the educator leading, supervising, participating and observing different educational activities. During many of these activities, the interaction with the students are very intensive, while other activities are less intensive. In face-to-face activities, the teacher obviously communicates and establishes a dialogue with the students. Figure 1 below is an outline of the Tracker architecture.

The educator gives advice and provides feedback to a certain extent, but time is limited and often there are many students. The educator make short notes, often mental, about the discussion and try to get back to the students later. An additional design issue was a conviction that educators need to reflect before providing feedback on an educational activity [12]. That is, in the classroom the educator is requested to provide immediate feedback on for instance a presentation or discussion.

With Tracker the educator has the opportunity to reflect and provide more well thought-out feedback than in an on-line case. The idea was to design Tracker so that small notes could be penned into a database during the different activities. The interface was designed as general as possible but still capable of storing information about different educational activities.

As Tracker supports non-criterion assessment, most of the interaction with Tracker is via handwriting recognition. The interface of Tracker is mainly two different types of screens. Individual view (see figure 2), and group view. The individual view consists of a page, or record, for each student. It is divided in four sections. First there is a demographic section for name, e-mail, code and picture. The code is used when presenting the information and at the same time maintain anonymity. The second section consists of a number of A through F parameters. They are used to grade certain activities when this is appropriate. What to grade this way can be negotiated with the students. Next is the 'Public' section, where the educator enter notes to give feedback to the student.

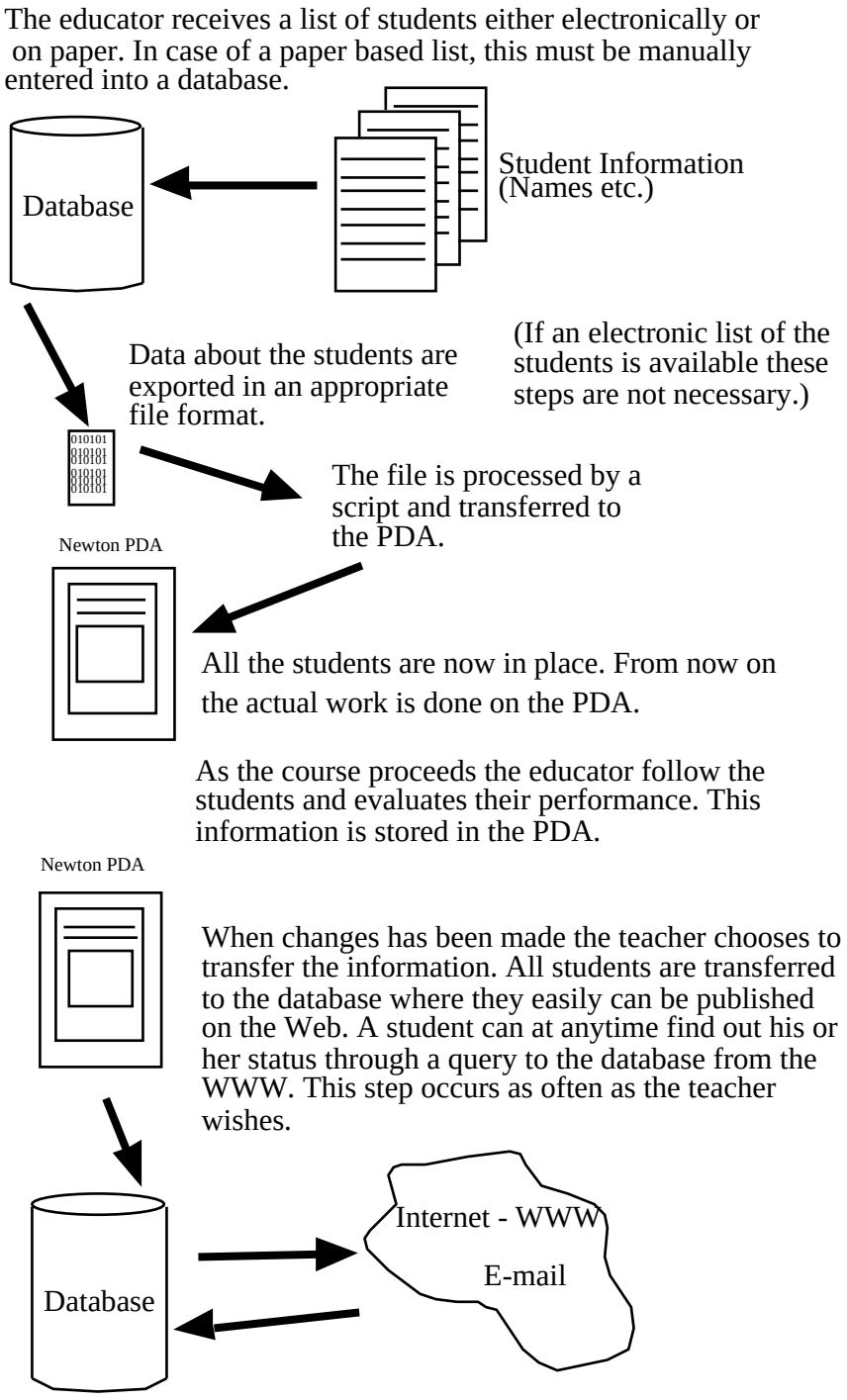

Figure 1: Tracker Architecture

These notes become public so all interested can take part of them. In other words, these are the comments and questions of common interest. The 'Private' section on the other hand, contains comments that are send only to the student via e-mail routing. Generally, the use of e-mail for

communication is discouraged as only a few individuals are involved in the interaction, but here it is a suitable tool.

The group view is similar to the individual with a few differences. It contains the name of the group as well as the names of its members. The group view does not include the 'Private' section as the comments are not directed towards a single student.

Figure 2: Tracker Interface

After an educational activity the teacher retires to reflect on the work of the students and on her own work. The short notes made earlier in the Tracker database are expanded. The aim is to formulate substantial feedback in the format of questions or comments. When appropriate, the teacher makes a connection to the local network and upload the data stored in Tracker. The uploads is easily conducted by connecting a cable from the Newton to a networked computer. A script controls the transfer to the database on the WWW server. When uploaded to the server, feedback to groups and the public section from the individual comments are available for the students. The interface towards the students is standard WWW based forms. A number of predefined queries are made

but the students are free to define queries according to their own interest. When browsing the feedback, students are encouraged to provide comments and additional questions. This way, students are able to follow the instructors assessment and they are also able to question the teachers grading during the progress of the course. Comments from the private section are filtered out when downloaded from the Newton and sent out via e-mail to the individual student.

7. Tracker in Action

Tracker was tested in an experimental setting. The purpose was to validate the principle of alternative assessment and to test the functionality of the prototype. A senior professor and eight undergraduate students were invited to participate in the testing. To prepare for the test, the professor was equipped with Tracker installed on a Newton. He received a short instruction on how to operate Newton. He then spent a few days becoming comfortable with the pen-driven interface and the Tracker application. For this purpose, Newton has several built in tutorials.

The session took place in a regular lab where the students were equipped with a personal computer. The notion about product and process oriented assessment was introduced to the students. Also the functionality of Tracker was explained to the students. Screen shots of Tracker were presented and they had opportunities to ask questions. A short discussion followed. The students were then asked to articulate their feelings and spontaneous comments about Tracker during the actual testing.

To make the testing somewhat close to reality, two scenarios of educational activities were developed. The first scenario described an activity, divided into three phases. The first phase involved discussions in smaller groups where the students presented their idea of project. The second phase was the guiding of the first outline of the paper. And the third phase was the professor walking around the poster session looking at the different posters. The professor was asked to think out loud while listening to the scenario and penning in the notes. After each phase, the professor were asked to comment the phase using Tracker and then connect and upload the feedback to the Web. The students were asked to read, discuss and comment on the feedback they received. This was repeated for all phases in the scenario.

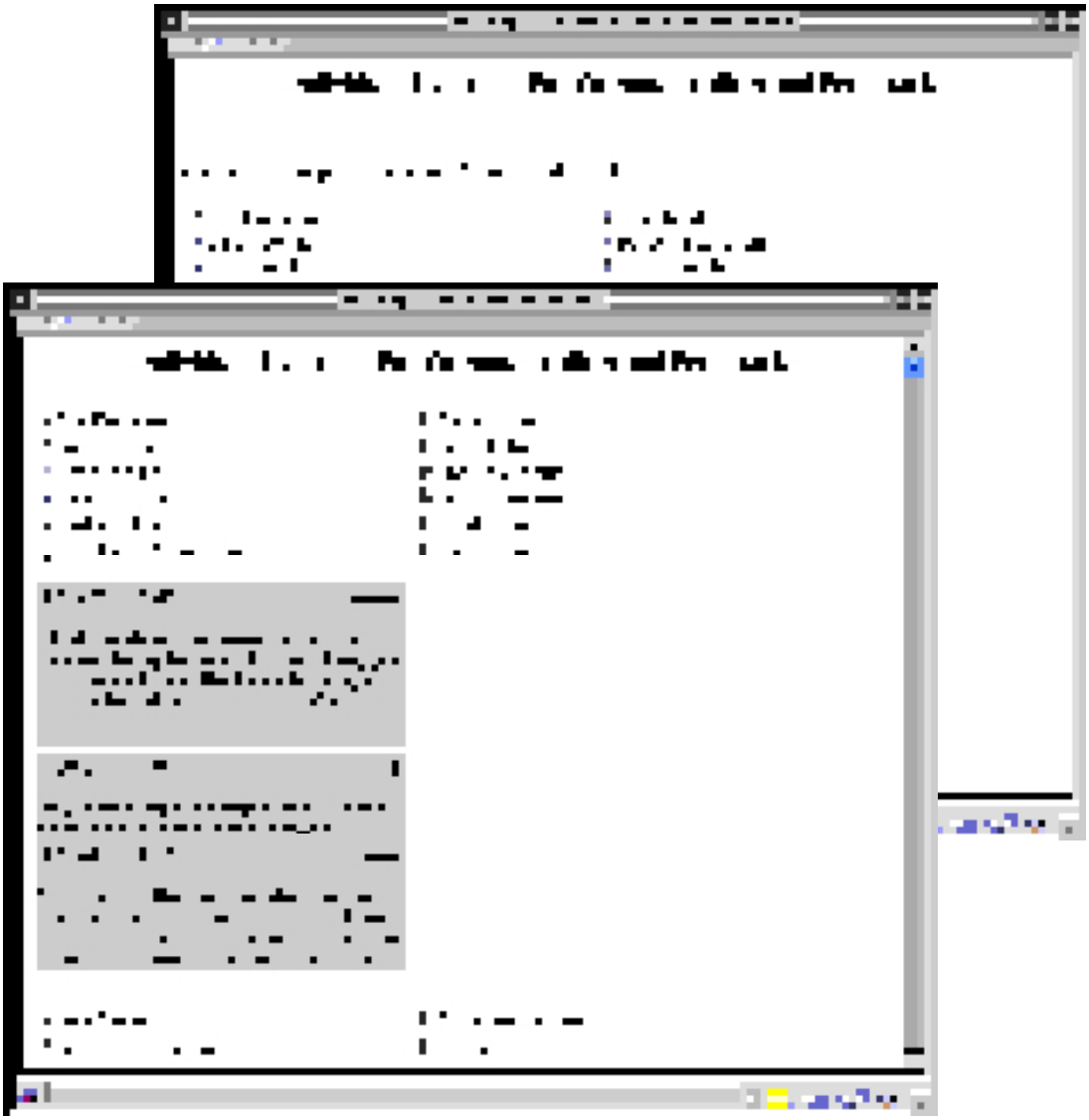

Figure 3: Tracker Web interface for individual feedback

The second scenario involved a group project. The first phase described a lecture where the assignment was handed out. The second phase described the groups working during the week and how they were facilitated by the teachers. And the third phase described the group presentation at the end of the week. The same procedure as in the first scenario was repeated here.

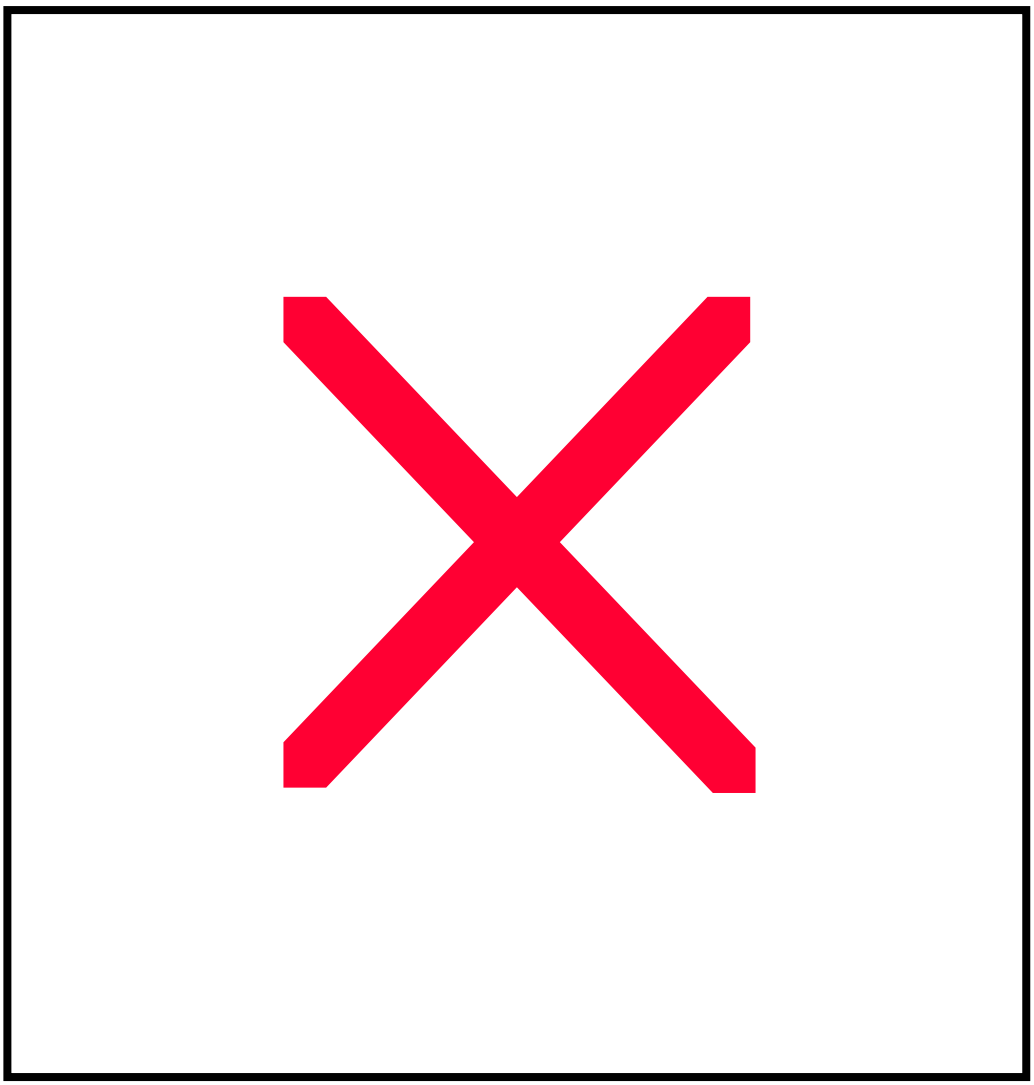

Figure 4: Tracker Web interface for group feedback

From leading scenario and observing the session it is obvious that Tracker is working. The evaluation experienced no technical problems. The professor as well as the students were impressed by this fact. The professor concluded his testing by stating: "Contemporary assessment system is based on the notion of negative feedback. This tool is certainly a reaction to this." The students agreed on the usefulness of Tracker. During the discussion they stated that the open feedback is lacking today and that it is welcomed. But, the students participating in the evaluation also raised some concern about the necessity of engagement among the students.

8. Discussion

In this paper I have discussed an alternative model to traditional assessment and examination in higher education. A mobile computing software, Tracker, was described and presented as a tool to facilitate the implementation of the alternative model. Tracker was evaluated in an experimental session. The evaluation was successful and resulted in additional issues for the future development of Tracker.

Whereas rationalization is central to current application of educational technology, it should be obvious that Tracker is not an effort in this direction. On the contrary, the ExCon project suggest a migration towards a more complex and demanding assessment system. It is claimed that Tracker can support the strive to influence grade-oriented students to become more learning oriented. To the objectivist and control oriented educator, Tracker probably makes no sense. But to those who subscribe to the ideal of the constructive and cooperative model of learning it probably does.

(Please note that figures 3 and 4 are not appearing in the original paper. This because there were limited page space in the proceedings.)

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9. References

1. **Harasim, L., et al., Learning Networks - A Field Guide to Teaching and Learning Online. 1995: The MIT Press. 376.**
2. **Hiltz, S.R., *Impact of college-level courses via Asynchronous Learning Networks: Some Preliminary Results.* Journal of Asynchronous Learning Networks, 1997. 1(2): p. 1-19.**
3. **Patton, M.Q., *Qualitative evaluation and research methods*. 2nd ed. ed. 1990: SAGE Publications, Inc.**
4. **Gibbs, G., *Research into Student Learning,* in *Research, Teaching and Learning in Higher Education*, B. Smith and S. Brown, Editors. 1995, Kogan Page Limited: London. p. 17-29.**
5. **Ramsden, P., *Learning to Teach in Higher Education*. 1992, London: Routledge.**

6. Leidner, D.E. and S.L. Jarvenpaa, *The Use of Information Technology to Enhance Management School Education: A theoretical View*. MIS Quartely, 1995. 19(3): p. 265-291.

7. Slavin, R.E., *Cooperative Learning: Theory, Research, and Practice*. 1990, Engelwood Cliffs, NJ: Prentice Hall.

8. Hawkins, J., *Technology and the Organization of Schooling*. Communications of the ACM, 1993. 36(5): p. 30-35.

9. Rogers, C., *Freedom to Learn*. 1969, Columbus, Ohio: Charles E Merill Publishing Company.

10. Bourne, J.R., *et al.*, *Paradigms for On-Line Learning: A Case Study in the Design and Implementation of an Asynchronous Learning Networks (ALN) Course*. Journal of Asynchronous Learning Networks, 1997. 1(2): p. 38-56.

11. Sproull, L. and S. Kiesler, *Connections - New ways of working in the networked organization*. 3 ed. 1993: The MIT Press.

12. Schön, D., *The Reflective Practitioner*. 1983, New York: Basic Books.

Appendix 1

Below is a list of publications related to my Ph.D. studies and this thesis.

Nuldén, U. (1996). Escalation in IT Projects: Can We Afford to Quit or do We Have to Continue. Information Systems Conference of New Zealand, Palmerston North, New Zealand, IEEE Computer Society Press. 136-142.

Nuldén, U. (1996). Failing Projects: Harder to Abandon Than to Continue. Projectics, Bayonne, France, Communications Proceedings. 63-74

Nuldén, U. (1997). Designing Environments for Reflection and Collaborative Learning. The 9th Annual Convention and Conference of Australasian Association for Engineering Education, Ballarat, Victoria, Australia. 325-329.

Nuldén, U. (1997). Running future workshops to enhance and improve education. The Eight International Conference on the Society for Information Technology and Teacher Education (SITE), Orlando, Florida, AACE. 919-922.

Nuldén, U. and H. Scheepers (1998). Computer Supported Problem Based Learning: The case of project failure. Sixth European Conference on Information Systems, Aix-en-Provence, France. 1704-1712.

Ellis, A, L. Carswell, A. Bernat, D. Deveaux, P. Frison, V. Meisalo, J. Maayer, U. Nuldén, J. Rugelj and J. Tarhio. (1998). "Resouces, Tools, and Techniques for Problem Based Learning in Computing." SIGCSE Bulletin inroads, 30(4): 45-60.

Nuldén, U. (1999). Thematic Modules in an Asynchronous Learning Network: Designing introductory courses. The 32:nd annual Hawaii International Conference on Systems Science, Maui, HI, IEEE Computer Society.

Nuldén, U. and C. Hardless (1999). Activity Visualization and Formative Assessment in Virtual Learning Environments. In Selected Papers of the Tenth International Conference on College Teaching and Learning, Jacksonville, FL. 117 - 126

Hardless, C. and U. Nuldén (1999). Visualizing Learning Activities to Support Tutors. Extended abstract in the proceedings of CHI'99. ACM. Pittsburgh, PA.

Keil, M, L. Wallace, D. Turk, G. Dixon-Randall and U. Nuldén (1999). An Investigation of Risk Perception and Risk Propensity on the Decision to Continue a Software Development Project. To appear in The Journal of Systems and Software.

Gothenburg Studies in Informatics (ISSN 1400-741X)

1 **Ulf Sundin. A logic programming approach to information modelling and database design, May 1990.**

2 **Thanos Magoulas and Kalevi Pessi. En studie om informations-systemsarkitekturer (in Swedish), February 1991.**

3 **Peter Nordenstam. Individbaserade relativt öppna informations-system (in Swedish), February 1990.**

4 **Bo Dahlbom and Lars Mathiassen. Struggling with quality. The philosophy of developing computer systems, August 1991. (Revised edition, Computers in context. The philosophy and practice of systems design, Oxford: Blackwell, 1993.)**

5 **Börje Langefors. Essays on infology. Summing up and planning for the future, Edited by Bo Dahlbom, August 1993.**

6 **Bo Dahlbom (ed.). The infological equation. Essays in honor of Börje Langefors, March 1995.**

7 **Bo Dahlbom, Frederik Kämmerer, Fredrik Ljungberg, Jan Stage and Carsten Sørensen. Proceedings of the 18th Information Systems Research Seminar in Scandinavia, June 1995.**

8 **Bo Dahlbom, Fredrik Ljungberg, Urban Nuldén, Kai Simon, Jan Stage and Carsten Sørensen. Proceedings of the 19th Information Systems Research Seminar in Scandinavia, June 1996.**

9 **Agneta Ranerup. Användarmedverkan med representanter (in Swedish), August 1996.**

10 **Ole Hanseth. Information technology as infrastructure, November 1996.**

11 **Fredrik Ljungberg. Networking, September 1997.**

12 **Jan Ljungberg. From Workflow to conversation, October 1997.**

13 **Thanos Magoulas and Kalevi Pessi. Strategisk IT-management (in Swedish), March 1998.**

15 **Urban Nuldén. e-ducation, May 1999.**

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