Bjørn Faugli

NBLE
(Net Based Learning Environment)

Developing, structure, functionality, organizing and delivering

Høgskolen i Hedmark
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Summary:
This report describes and presents results from the PedTek (Pedagogy and Technology) Research and Development (R&D) project. The project was started in 1997 and the Norwegian Ministry of Education and Research granted 1 million Norwegian Kroner (approximately USD 140 000) in economical support. The overall goal of the PedTek project was to design educational solutions for physically handicapped and other students unable to comply with the requirements of ordinarily on-campus teaching. A four-component NBLE prototype was tested and continually redesigned during the experimentation. With reference to the predefined development goals it can be concluded that Hedmark University College (HUC) in particular and readers of this report in general now are in a better position than before to provide efficient net based education programs for off-campus students applying PBL and CL based pedagogy. The four-component structure NBLE, consisting of Pre-produced learning material, Learning Management System, Supervision and exercises and Face to face meetings and workshops, represents a convenient model for implementing computer-supported learning processes for off-campus students.
The more obvious research results include the identification of a set of critical variables, providing a background for suggesting designs of user adaptive NBLEs. By considering Learner's motivation, Learning culture, Consequence of failure, Duration of the learning process and Type of curriculum it is hypothesized that pedagogy based on different learning theories should be applied. Recommendations related to the use of the R&D results in practical situations are that the implementation of Net Based Learning Environments in organizations not should be considered a trivial task. The implementation process should be defined and conducted as a proper experimental systems development project.

Høgskolen i Hedmark

Tittel: NBLM (Nett Baserte Lærings Miljøer). Utvikling, struktur, funksjonalitet, organisering og levering.

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Sammendrag:
Denne rapporten beskriver og presenterer resultater fra forsknings og utviklingsprosjektet PedTek (Pedagogikk og Teknologi). Prosjektet ble startet i 1997 og Det Kongelige Kirke, undervisnings og Forskningsdepartement bevilget 1 mill. kroner i økonomisk støtte til prosjektet. Den overordnede målsettingen for PedTek prosjektet var å utforme utdanningsløsninger for studenter med bevegelseshemning og studenter som av andre grunner ikke kunne følge ordinær undervisning med fysisk tilstedeværelse ved et lærested. En fire komponents NBLM prototyp ble testet og kontinuerlig modifisert i løpet av eksperimenteringen. Med referanse til det forhåndsdefinerte målet for utviklingsarbeidet kan det konkluderes med at Høgskolen i Hedmark (HH) spesielt og lesere av denne rapporten generelt nå er bedre i stand til å tilby nettbaserte læringsløsninger for fjernstudenter ved å anvende PBL og samarbeidslæring. Den fire komponents NBLM strukturen består av Forhåndsprodusert læringsmateriell, Nett-basert kursstøtte system, Veiledning og oppgaver og Ansikt til ansikt møter og representerer en hensiktmessig modell for etablering av læringsprosesser for fjernstudenter.
Av de mer åpenbare effektene av FoU prosjektet kan det pekes på identifiseringen av et sett kritiske variabler som gir bakgrunn for å foreslå brukertilpassede utforminger av NBLM. Ved å trekke inn studentenes motivasjon, læringskultur, konsekvenser av å ikke nå oppsatte læringsmål, læringsprosessens varighet og type pensum, kan det framsettes hypoteser om at pedagogikk basert på ulike læringsteorier bør anvendes.
Anbefalinger knyttet til bruken av resultatene i praktiske situasjoner er at implementering av nett baserte læringsmiljøer i organisasjoner ikke må betraktes som enkle og trivielle oppgaver. Implementeringsprosessen bør defineres som et virkelig eksperimentelt systemutviklingsprosjekt.

Preface

In 1993, Hedmark University College (HUC) was invited by the Norwegian Organization for Handicapped Youth (NHFU) to collaborate in planning and designing distance education solutions for physically handicapped persons. A project team was established and it was decided to focus on the possibilities of reorganizing the existing undergraduate Computer Science program at Hedmark University College as distance education for physically handicapped. In 1994 the project team presented a report, sketching some preliminarily solutions. Based on this report the Norwegian Ministry of Education and Research initiated an extension of the project and in late 1995 a comprehensive report was published (Faugli B. 1995, Høgskolestudium i Informatikk for bevegelses-hemmede. (In English: College education in Computer Science for physically handicapped persons). The report proposed organizational, pedagogical and technical solutions based on the, at the time, existing state of knowledge and technology and attempted an extrapolation to suggest solutions for the future. However, the technological development rate and the progression in gaining experience with distance education makes the life span of new ITC-based systems and solutions relatively short. A continuous development process is in particular required in this field if the potential of modern technology is to be utilized. On this background the PedTek (Pedagogy and Technology) project was started and in 1997 the Norwegian Ministry of Education and Research granted 1 million Norwegian Kroner (approximately USD 140 000) in economical support. This founding from the Ministry has been a prerequisite for conducting the PedTek project and allowed Hedmark University College to embark on an extensive experimental development program. The main objective of the PedTek project was to design educational solutions for physically handicapped and other students unable to comply with the requirements of ordinary on-campus teaching. The experimentation process of PedTek was terminated in fall 2000. However, in January 2001, Hedmark University College granted additional economical R&D resources, allowing the PedTek project to be extended into a Phase II (Faugli B. 2000. PedTek Fase II) terminated in fall 2002. The development process of the PedTek project is based on conducting experiments with undergraduate courses in Project Management and Systems Development attended by Computer Science students at Hedmark University College. Prototypes have been developed, tested, revised and re-tested continuously for a period of six years. The present report describes the background, the development process and the results from analyzing and interpreting empirical data and experience from the PedTek project. As a final comment it is appropriate to point out that this report from the PedTek project is long overdue. However, the delay is mainly explained by the fact that the learning process of the developers has accelerated throughout the project. The rate of gaining new knowledge has been considerably higher at the final stages of the project than at the beginning and this has made it difficult to decide when to stop exploring and present concluding comments. The present report is written in English with the purpose of increasing the availability of the results and accordingly provide for useful feedback from the international research community

Acknowledgements

Conducting the development process has involved a large number of persons and institutions. These have made contributions varying from establishing the necessary theoretical framework, creatively suggesting alternative solutions, assisting with practical tasks to providing economic resources. Not all contributors can be given the credit they deserve in this report, but a few tower above the others and must be mentioned. During the pre-project stage the planed progression of the experimental process and the theoretical framework was described in detail (Faugli B, Fjuk A, Øgrim L, 1997). Pedagogikk og teknologi for distribuerte læringssituasjoner). The theoretical framework presented in this document is largely a result of research conducted by Annita Fjuk and Leikny Øgrim prior to the PedTek project. Annita Fjuk (Telenor Research & Development) and Leikny Øgrim (Oslo University College) also made extensive contributions during the first stages of the experimental process, both as active instructors/teachers and providers of inspiration and new ideas. However, during the final stages of the project and in particular during the writing of the present report, Leikny Øgrim sacrificed part of her summer vacation 2003 to read the draft and has contributed with invaluable advice and comments. Many thanks Leikny. I owe you a compensation for coming close to dehydration in the summer heat of 2003 and Ribbung a bone and stick-fetching exercises. During large parts of the project period my colleague through many years, Brit Svoen, has contributed in many ways towards reaching the present results of the PedTek project. The project has particularly benefited from Brit's knowledge, competence and insight in designing web-based solutions based on theories of learning and pedagogy. Her commitment to tasks, reliable delivering of results, creative abilities and role as source of inspirational has been invaluable to the progression of the project. The project has also had the pleasure of involving Pia Vangen and Atle Røijen for generating new ideas, planning and taking care of the demanding task of conducting workshops. The excellent service provided by the library at HUC, Rena must also be mentioned. They are standing out as a particularly service minded and professional part of the HUC organization and a

special thank to the librarians, Magni Melvær and Anne Myrtrøen. In addition the project whishes to thank colleagues at the computer science department and the many computer science students who has endured the experimentation and in some cases been guinea pigs. During the later stages of the project, I have also benefited from the dialogue with the four master degree students, Ronald, Marit, Eirik and Tone I am supervising. Conduction colloquium sessions with these students have forced me to more carefully consider issues related to on-line learning. A special thank to Marit Berg who has contributed to improvements of the English language and made the report more readable. But, as the author, I am responsibility for both the form and contents of the report. It is, however unquestionable that without the economical support from the Norwegian Ministry of Education, Research and Church affairs the project could not have been conducted in a satisfactorily way. Hopefully the results and conclusions presented in this report represent a satisfactorily product in exchange of the money spent. Conducting the project has also required the contribution of considerably resources from Hedmark University College, not only in economical terms, but also by providing various forms of support during the experimentation. Granting economical means for extending the project to PedTek phase II is highly appreciated and represent a valuable support.

Contents

Introduction

Background

Information and Communication Technology (ICT) is expected to play an increasingly important role, as a component in educational systems in the years ahead. IC technology is considered to have a great potential for enhancing the quality and efficiency of learning-processes and making educational programs accessible for larger proportions of the population. Since the start of organized learning in societies, with the establishment of schools and universities as formal educational institutions, it has been required that learners and teachers meet face to face in classrooms or lecture theaters. With a few exceptions, this has been the only practical way of organizing effective communication and interaction between learner and teacher and efficiency considerations have further reinforced this organizational solution. Cost efficiency considerations favor the gathering of large number of learners within hearing distance of the teacher. These considerations and requirements represent frameworks, imposing considerably limitations on the freedom to choose alternative ways of organizing education and restrict the options of applying suitable and efficient pedagogy for conducting learning processes. Formal learning processes have traditionally been based on transfer of knowledge directly from the teacher to the students, applying a pedagogy, which can be characterized by a knowledge PUSH approach, where the learners are passive receivers of knowledge.

> «the teacher lectures and the student listen. Children assume the role of passive, rather than active participants. It is as if the knowledge the teacher has can be transmitted directly to the students; the metaphor is that of pouring information from one container (the teachers head) to another (the students head).» (Brown, Campione 1990)

The development of powerful computers, high capacity data communication, advanced software and in particular availability of the Internet, during the last decade, has created new, favorable conditions for constructing efficient flexible learning systems. It allows realization of flexible learning processes where learners can choose the time and place to study and the teachers are freer to apply appropriate pedagogy. For the past half a century, flexible learning solutions have been successfully available through traditional distance education programs, organized as correspondence courses. However, with modern ICT, the conditions for delivering distance education, is dramatically changed. With lifelong learning on the agenda, worldwide, efficient and flexible educational programs of high quality are expected to be increasingly in demand. A growing proportion of the population needs continuously refill of knowledge or a more comprehensive reeducation to comply with the rapidly changing working life conditions. Many of these learners are fully or part time occupied in jobs, have family obligations, reduced mobility due to handicaps or are for various other reasons unable to spend long periods of time with physically presence on campus. Off-campus students represent a new category of learners requiring flexible learning conditions and constitute a new an important part of the student market. Providing efficient and high quality educational programs for this new category of students is today a major challenge for most educational institutions.

Numerous educational institutions are promoting net-based educational programs for off-campus students as better or satisfactorily alternatives to traditional on-campus programs. E-learning has become a fast growing and prosperous business and with a variety of educational programs available in the market, it was not immediate obvious, at the start of the PedTek project, that it was necessary to embark on a comprehensive development project to implement off-campus educational solutions. Applying existing standard systems already in operation was an alternative. Based on this, during the initial stages of the PedTek project, an informal survey was conducted, investigating the performance and functionality of available Net Based Learning Environments (NBLE), but none satisfied the preliminary systems requirements. Most NBLEs appeared to be implemented as high-tech solutions for off-campus students using powerful computers and the Internet without achieving more than could be accomplished by using old-fashioned books, chalk and blackboard and sometimes not even that. The IC technology is frequently superimposed on traditional lecture-based learning processes. A prevailing attitude among many ICT specialists and educators seems to be that with access to the Internet it is trivial to organize and deliver off-campus education programs. This attitude is reflecting an insufficient understanding of the complexity of developing and implementing systems involving people, technology and organizational issues.

> «when educational IT is examined there is often little evidence of it being grounded in any learning theory» (Jones A. 1996).

And when a connection to learning theory is apparent it is frequently related very traditional pedagogy.

> «Instructional theories, though, which have been influential in American educational software design, have in the main drawn on behaviorist ideas» (Jones A. 1996).

The state of knowledge in this field, at the start of the PedTek project, indicated clearly that designing e-learning systems for off-campus students is far from a trivial task.

> «it is extremely difficult to develop good CSdCL (Computer Support for distributed Collaborative Learning) products anchored in the principles of lifelong learning» (Fjuk A. 1998).

And further:

> «it is yet a huge challenge to offer the students, often collaborating from homes, computer-based solutions that serve to support their collaborative learning process» (Fjuk A. 1998).

However, the presence of internet-based educational programs with unsatisfactorily quality may not entirely be contributed to insufficient understanding of the tasks involved. It is reasons to suspect that in some cases, the driving force behind implementing less satisfactorily solutions may be the desire to make fast profit in a new and expanding commercial marked. But dealing with the latter is clearly beyond the scope of the PedTek project.

With this point of departure the PedTek project was initiated in 1997. The primary objective was to conduct an experimental development process with NBLE designs, combining web-based instructional technology with supporting pedagogical solutions based on constructivist learning theory. The practical goal of the development process was to realize and implement efficient, high quality

Net Based learning Environments (NBLE) for off-campus students. The secondary objective of the project was to conduct research, based on experience gained by observations and studies of the experimental development process. The research goals where to continuously acquire knowledge for feedback to the experimental development process and to gain general knowledge in the field of net based learning. Both the start of the project and the process further is based on and strongly inspired by the research of Annita Fjuk in her exploration of issues involving the use of instructional technology for the support of collaborative learning in distance education. (Computer Support for distributed Collaborative Learning (CSdCL). Exploring a Complex problem area Fjuk A. (1998) Dr. Scient thesis. University of Oslo). The quintessence of this research is that collaborative learning supported by web-based technology represents solutions with a promising potential for distance learning. But care must bee taken to understand CSdCL in terms of the tension between the three aspects: Collaborative learning, Distance education and Asynchronous computer mediated communication. In 1998, this field of R&D had still many unsolved problem areas and Fjuk (1998) concludes that CSdCL is just in the beginning of a path of finding good solutions. This clearly indicated that the potential for satisfactorily NBLE solutions was present, but considerable research and development effort was required to utilize the potential.

Development objective

The objective of the development process was to Design an efficient and flexible Net Based Learning Environment (NBLE) for off-campus students, applying pedagogical principles based on Collaborative Learning (CL) in combination with Problem Based Learning (PBL).

The application of computers in education can be traced back to the early 1960ties, but until recently, computer applications have been limited to peripheral and supplementary support functions for traditional learning processes. Computers have rarely been included as a major component in educational systems and consequently the available experience from this type of applications was limited. However, for several decades, computers have extensively been incorporated as a major component of information systems in small and large, private and public enterprises and organizations and from R&D in this field, considerably experience has been gained. In particular the many, less successful projects involving information technology, some with catastrophic results, have contributed to a better understanding of the challenges and pitfalls involved in developing and implementing computer based information systems. With increased appreciation of the complexity of introducing computer-based information systems in organizations, Systems Development has become a correspondingly important profession. Experience from the field of systems development clearly indicates that successful implementation of IC technology require that great care is taken, when conducting the systems development process, in understanding the organizational context of the technological system. Combining modern technology with old organizational solutions and traditional division of work tasks rarely result in optimal solutions. With the objective of developing Net-Based Learning Environments for off-campus students, the PedTek project was confronted with a type of tasks having considerably similarities with what is involved in the process of developing comprehensive computer-based information systems. In the same way as most other computer-based information systems, the NBLE consists of a combination of people, technology and an organizational structure. In an NBLE these elements are represented by students, teachers, instructors, the Internet, computers, pedagogical solutions and educational organizations. On this background the PedTek project embarked on the process of developing and implementing a NBLE, strongly inspired by an experimental systems development approach.

> «Good CSdCL practices are only developed through evolutionary experimenting of the technology and of various pedagogical methods that constrain and condition its use.» (Fjuk A. 1998)

Applying an experimental approach in systems development is becoming increasingly more common and implies that the development work is started without having defined a comprehensive and final systems requirement specification. The systems user requirements gradually evolve as a result of testing, evaluating and redesigning prototypes during the development process. Applying experimental approaches is based on many years of experience from the field of systems development, which clearly indicates that with traditional systems development approaches most systems requirements are considerably changed during the course of a development project.

> «The user requirements as a basis for the projects could not be described completely. New requirements emerged throughout the projects. As a consequence, steps back to the previous development phases had to be taken continuously» ….. «prototyping is a strategy for performing requirements determination wherein user needs are extracted, presented and developed by building a working model of the ultimate system – quickly and in context.» (Boar 1984 in Kautz. K Dr. Philos. Thesis 1993)

With experimental systems development, an initial analysis is performed and a preliminary systems requirement specification is produced at the early stages of the development process.

The first prototype of a NBLE for the experimental development process in PedTek was designed in 1997 with basis in practical experience from other projects, prior to PedTek. In particular, great care was taken to include functionality in accordance with PBL and collaborative learning (CL) theory. The result was realization of an NBLE prototype with the following four-component structure:

1. Pre-produced learning material (books, articles, video/film)
2. Learning Management System (LMS)
3. Supervision and exercises
4. Face to face meetings and workshops

Based on constructivist learning theory and in particular the work of Piaget and Vygotsky, an operational NBLE prototype was designed in accordance with guidelines from CL (Collaborative Learning) and PBL (Problem Based Learning). This represented a learning environment, very different from the traditional knowledge-PUSH-based way of organizing learning processes. The objective was to provide the students with favorable conditions for «pulling» required information from a surrounding support system and allowing the construction of new knowledge.

During the project period, six prototype versions of a Net-Based Learning Environment (NBLE) for an undergraduate course in Project Management was designed, tested, evaluated and redesigned. Evaluation of the prototypes performance was conducted by collecting empirical data using questionnaires, interviews and participant observation. Prior to the PedTek project a similar curriculum was used for several years in a traditional, lecture-based course in Project Management, attended by the same category of undergraduate students who was exposed to the prototypes during the PedTek experimentation. Experience from this traditionally organized course allowed for valuable comparisons of the traditional and the new learning environments. With the PedTek-objective of realizing a high quality NBLE for off-campus students, the prototype performance was evaluated with main focus on the following four criteria of success: Learning Outcome, Degree of Flexibility of the learning processes, Resource Requirements and Learners Satisfaction.

It is however, important to emphasize that «The right NBLE solution» for all conditions and situations does not exist. In some cases it may be acceptable to use large resources to ensure high Learning outcome or high degree of flexibility or both, but in other situations, a different dosage and combinations of these factors may be preferable. The development process in PedTek focused mainly on the NBLE performance in a particular situation with undergraduate Computer Science students attending a 2-credit course in Project Management.

Research focus

The objective of the research activity in PedTek was to continuously acquire knowledge as feedback in support of the development process and to gain general knowledge in the field of NBLE. Focus has particularly been on the experience gained by researchers in the field of Computer Support for Collaborative Learning (CSCL). The research process was closely related to the development process as a means of interpreting the test results and provide feedback for redesign of prototypes and used the development process for gathering empirical data. The development process performed experiments by testing NBLE prototypes with undergraduate computer science students following a course in Project management at Hedmark University College. This imposes some limitations on the generalization of the research findings in PedTek. Extrapolating the PedTek results to other situations introduces varying degrees of uncertainty, depending on how these situations differ from the actual PedTek case. An experimental development process with focus on the NBLE performance with respect to Learning Outcome, Flexibility, Resource requirements and Learners Satisfaction calls for a representation of these factors by operationalized variables. The more precisely the variables can be defined and operationalized the more precisely the performance of the NBLE can be measured and the more focused and efficient the evaluation and redesign of the prototypes can be conducted. For the experimental process in PedTek, variables representing the main determining factors, or success factors, for the overall performance of the NBLE, can to a reasonably degree be given operational definitions. It is however, important to emphasize the epistemological nature of the research process in PedTek. During and in the aftermath of the development process the researcher's understanding and insight in the problem area were considerably enhanced by the effect of experiencing less predictable phenomena. These phenomena must be taken seriously and challenges a traditional, positivistic approach. An important effect of this was, as the development process progressed, that we were able to provide answers to questions, which we earlier not even were able to ask (from: S. Sjøberg, Doctoral thesis, 1981).

And further, a consequence of this is that the conclusions and recommendations from the PedTek experimentation are based on both the analysis and interpretation of empirical material from the positivistic inspired observations conducted and the retrospective, reflective process. The retrospective, reflective process directed our attention to factors and situations that we previously had given low priority or ignored. In the present analysis of the PedTek experience this represent shortcomings that not can be fully compensated for. However, future research based on PedTek can benefit from this experience by allowing the forming of hypothesizes which can be tested during new experimental development processes.

In chapter 1 of this report, the theoretical background of learning and education and the relation to technological support of the learning process is presented.

In chapter 2 the theoretical background of the R&D process, the process of collecting empirical data and some analysis results are presented and discussed.

Chapter 3 and 4 presents the main analysis results and interpretation of the empirical data and the discussion and presentation of recommendations. Chapter 3, Structure and Functionality of Net Based Learning Environments (NBLE) is concerned with the pedagogical and technological aspects. Chapter 4 is dealing with challenges involved when implementing NBLE solutions in practical, educational organizations.

Chapter 5 presents conclusions and recommendations based on the R&D process.

The last part of the report contains literature references.

1. Learning, education and technological support

Understanding how learning takes place and why most of the present educational systems are organized the way they are, is a prerequisite for designing efficient Net Based Learning Environments (NBLEs). This is particularly important in view of the heavy impact modern Information and Communication Technology (ICT), with the Internet, have and is expected to have as a mediating tool and artifact in learning processes. Many of to days NBLEs are designed without utilizing the potential of modern ICT as a scaffold for supporting learning processes because they fail to combine technology, people and organizational aspects in optimal ways. Approaches commonly applied when designing NBLEs can be characterized as «solutions search for problems».

> «A frequent charge leveled against technological innovations in education is that they often seem to be designed to exploit the capabilities of the technology rather than designed to meet an instructional need; that is, that they are technology-driven rather than theory based.» (Koshmann T. Kelson A. C. Feltovitch P. J. Barrows H. S. 1996)

The technology, with all its advanced and fascinating possibilities, represents a temptation many ICT experts find hard to resist. NBLEs are frequently designed and implemented with functionality and structure the engineers believe will support learning processes. This is often based on insufficient insight in how people learn and how educational programs are organized and the consequences are often sub optimal solutions.

Achieving optimal solutions require insight in the possibilities and limitations of established pedagogical principles and educational systems. Experience from the field of systems development clearly indicates that attempts to combine modern technology with «old fashion» organizations do not result in optimal solutions.

Many available NBLEs fail to combine technology and pedagogy in a satisfactorily way. High-tech solutions, using powerful computers and the Internet, are frequently applied without achieving more than could be accomplished by using old-fashioned books, chalk and blackboard and sometimes not even that. The IC technology is either superimposed on traditional lecture-based learning processes or used for providing learning material for self-studying programs. In both cases the potential of the IC technology, for supporting learning processes, is unsatisfactorily utilized.

In many cases there are reasons to suspect that the designer's conceptual pedagogical framework is imposing limitations on the design process. By being caught up in traditional conceptual frameworks, considering learning as an activity limited to classrooms or lecture theaters, with teachers pushing knowledge across to the students, the design of NBLEs is considerably limited. Frequently, metaphors such as virtual classrooms are used, indicating that the ideal or optimal solutions are NBLEs with a functionality as close to the classroom situation as possible. With limited knowledge of how people learn and why educational systems are organized the way they are, this is only what to expect. However, if we search for improvements of the present pedagogical and educational solutions we need a more comprehensive understanding of learning and education. Only on this basis, the performance of existing educational solutions can be surpassed.

Most important is that designers and educators should strive to free themselves from traditional thinking and become more imaginative. Cutting strings to the traditional, familiar and safe situation of the lecture theatre is perhaps the biggest challenge, and this requires visions of better alternatives. Applying alternative pedagogy is challenging our courage. Our reluctance to adapt new pedagogy can to some extent be explained by the psychology of rituals. When students enter the classroom or lecture theatre, they participate in a ritual, traditionally considered as a learning situation. Being present during a lecture gives the student a feeling of acquiring new knowledge and having complied to this, the student will easily be content and have a feeling of being in a learning situation, mainly because the educational institution has convinced them that the lecture theatre is the main learning arena. The same reasoning can be applied to the teachers and lecturers. Having performed in the classroom or lecture theater gives a content feeling of having «done the job». In addition, reluctance to adapt new methods is also, in many cases, a matter of choosing the path of less resistance and effort.

> «You don’t have to teach students anything. Just make sure that proper conditions are provided. Make sure that the students feel that their work and effort is appreciated. And that they are rewarded in one way or another. Your task is to give them time, space and energy. Then they will start to observe, listen, systemize on their own. The learning ability and possibilities are latent I each student. Place yourself in the background. Don’t talk much. Give the students white and unused sheets of paper. Let the students talk. You will not be lacking material. You have to be brave. The biggest obstacle is modesty and habits that you find amongst most academics. Consider the space, the time and the energy you allow yourself. Not quite satisfied with this? Turn it upside down. Ask yourself what is important for you. Don’t critizice yourself. Just change. Then you will start to learn yourself. Together with the students … It always starts with curiosity. And it continues with the right to ask questions.» (Ann Kerwin. 1995 University of Arizona)

We reach our learning goals best when we are provided with appropriate conditions and it is important to keep in mind that this is not necessarily by spending time in a lecture theatre.

1.1 The evolution of education

> «In prehistoric times we were all hunters, either as predators or vegetarians searching for plants. Social organizations was limited to the formation of smaller groups or the family and most of the time was spend, engaged in activities with the purpose of catering for the satisfying of basic needs such as search for food and shelter. The learning process, of each individual, is believed to mainly be a matter of adapting the behavior of the more experienced members of the group such as biological parents or leaders of the group.» (Enc. Brit. 2003)

Cultures we commonly denote as modern civilizations have for the past few thousand years, evolved with different rate of progressions in different parts of the world. Efforts to systematically plan and organize learning processes and enhance the efficiency of learning processes are closely related to the evolution of modern cultures. When the sons' and daughters' professional careers was predetermined by the profession of their fathers and mothers, the teachers or mentors where available in a natural way. The boys spend the days with their fathers and the girls with their mothers and learned by doing under «natural» guidance. The sons became hunters, collectors or craftsmen like their fathers and similarly the daughters learned to cater for conditions at the camp, like their mothers. And as long as the career paths were determined by the parents' professions this natural educational system served its purpose well. And there are no indications or reasons to believe that the youngs' learning progression was less steep under these conditions than it is in present days educational system. The level of knowledge of a skilled hunter was probably not inferior to the knowledge level of today's' skilled carpenters or lawyers. The efficiency of the learning process of the young hunter was at least comparable, perhaps superior, to learning processes in modern educational systems. These old ways of training and teaching learners worked perfectly under the prevailing conditions up to a few hundred years ago. But gradually and in particular with the industrial revolution, societies became more complex with increased specialization and division of labor. When the sons and daughters of hunters, farmers and craftsmen wanted to pursue a different professional carrier than their parents the possibility of adapting the behavior of the experienced parents diminished. To cater for the learning requirements of a farmer's daughter who, for example, chose to pursue a carrier as a lawyer, it was necessary to organize education in new ways. Education had to be institutionalized and learners pursuing the same skills and competence were gathered in large groups to gain new knowledge by reading books and listening to teachers. The student factories emerged.

> «As societies grow more complex, however, the quantity of knowledge to be passed on from one generation to the next becomes more than any one person can know; and hence there must evolve more selective and efficient means of cultural transmission. The outcome is formal education – the school and the specialist called the teacher. As society becomes ever more complex and schools become ever more

> institutionalized, educational experience becomes less directly related to daily life, less a matter of showing and learning in the context of the workaday world, and more abstracted from practice, more a matter of distilling, telling, and learning things out of context.» (Enc. Brit. 2003)

Cost efficiency considerations favor the gathering of large number of learners within hearing distance of a single teacher. The traditional, formal learning processes of today's educational institutions are based on transfer of knowledge directly from the teacher to the students, applying a pedagogy, characterized as a knowledge PUSH approach, where the learners are passive receivers of knowledge.

> «The teacher lectures and the student listen. Children assume the role of passive, rather than active participants. It is as if the knowledge the teacher has can be transmitted directly to the students; the metaphor is that of pouring information from one container (the teachers head) to another (the students head).» (Brown, Campione 1990)

This can with reasonably degree of accuracy be characterized as «the state of the art» of our present educational systems. But in the context of applying modern instructional technology for supporting learning, alternative learning processes can be introduced. This is not necessarily a matter of new pedagogy. Old principles are reintroduced and contribute to enhancing the quality and flexibility. Pedagogical solutions such as Problem Based learning (PBL) and Collaborative Learning (CL) have proved to be interesting. This is based on principles of learning introduced more than two thousands years ago by the Greek philosopher Socrates. He claimed that true knowledge comes from the inside and cannot be introduced by «external forces». The teacher should take the role of a Midwife and help to deliver the learning processes. This is interesting principles of learning, but have for practical, economical reasons, not been applied to any extend in modern education. With modern ICT the old fashion principles can now experience a renaissance.

1.2 Theories of learning

Learning as a phenomenon is so varied and diverse that a definition in a single category may not be possible. Recognizing this, it is important to make clear that it is far beyond the scope of this report, attempting to make a comprehensive and general definition of learning as a phenomenon. No definition of learning is likely to be totally satisfactory. A definition proposed in 1961 by G.A. Kimble may be considered representative:

> «Learning is a relatively permanent change in a behavioral potentiality that occurs as a result of reinforced practice.»

But this definition is not particularly operational and useful for focused research activities. The terminology applied in the field of education includes, among several others, terms like pedagogy, didactic and learning theory, often used without precise definitions and distinctions.

The term pedagogy, defined in its broadest sense, is concerned with the general upbringing of children. In the pre industrialized period, before the establishing of formal educational institutions, the distinctions between general upbringing and training was less clear. But with the development of formal educational institutions the term pedagogy is commonly used in connection with methods for systematic knowledge enhancement in the formal educational system.

> «Pedagogy is the study of teaching methods, including the aims of education and the ways in which such goals may be achieved. The field relies heavily on educational psychology, or theories about the way in which learning takes place.» (Enc. Bri. 2003)

With this development it consequently became important to consider the specific challenges involved in organizing courses in different subjects with specific curriculums. This led to a focus on Didactic, which denotes the part of pedagogy concerned with general principles for good and systematic teaching.

> «The part of the teaching that deals with the teaching methodology, the science of teaching.» (Hilde T. 1997)

The presentation of theories of learning in this chapter is limited to what is considered necessary as a background for understanding the reasoning, argumentation, interpretations and conclusions in this report. On this background, theories of learning are discussed with particular attention to their relevance for and relation to instructional technology. It is not always clear what qualifies as «pure theories of learning». The distinction between theories and practical models derived from basic theories is vague. But clarifying this is also beyond the scope of this report and more an issue for the philosophy of science.

Instructional technology is a term commonly used for describing technology used for supporting instructions in a learning or educational context. It is not limited to a certain type of technology but rather technology in a wide sense of the meaning. The term Instruction denotes the communication between teacher and students.

> «A conversation between a teacher and student which provides feedback to the student about the content of the learning task as well as providing feedback to both the student and the teacher about the students progress in achieving the learning goals.» (Hamilton D. Bonk C. 1994)

By some, the term instructional technology is given a definition, not limited to what we commonly consider to be technology and certainly not limited to modern IC technology.

> «Instructional technology is the theory and practice of design, development, utilization, management and evaluation of processes and resources for learning.» (Don. P. Ely, 2000)

The table below gives a brief overview of the introduction of various kind of instructional technology.

Event marking Emergence of Paradigm	Theory of Learning	Model of Instruction
Introduction of Coursewriter (1960)	Behaviorist	Programmed instruction/instructional design
Carbonell's Dissertation (1970)	Information Processing Theory	One-on-one tutorial
Publication of Mindstorms (1980)	Cognitive constructivist	Discovery-based Learning
NATO Workshop (1989)	Socially oriented Theories of learning	Collaborative Learning

Table 1.1
Some Paradigms of research in instructional technology (From Koschmann T. 1996)

Learning theory is spanning a wide spectrum of principles and approaches. The extreme ends of this spectrum are represented by Behaviorist theory in one end and Constructivist theory in the other. Most theoretical and practical approaches to organized learning can be located along this dimension but their relation to the extreme ends are not always explicitly expressed.

The existence of different learning theories naturally raises the question of whether the various theories are exclusive or if each theory has conditional validity. Or phrased in a more direct way: If Behaviorism correctly describes how humans learn, is then other theories, such as Constructivism not correct? Or is it the case that Behaviorism is valid under certain conditions and Constructivism under other conditions in the sense that they are complementary? Experts and the scientific community don't agree on this and do not provide precise answers. The approach to experimentation applied in the PedTek project assumes that the various learning theories have conditional validity and hence, that different theories should be applied under different conditions. Learning processes should be adaptive and can and should under certain conditions be based on different theories of learning.

During the last decades, especially with the introduction of Internet as a system with a potential for supporting learning, a tendency of change in the terminology within the community of educational experts has taken place. A shift in terminology from emphasis on teaching to learning, classroom to learning process, knowledge push to knowledge pull, delivering to providing, Behaviorist to Constructivist and individual to collaboration can be observed. There are reasons to assume that this shift in terminology is reflecting an increased willingness and interest to approach the design of educational programs in new and untraditional ways. With respect to what is required for reaching more optimal solutions, combining technology and pedagogy, this is promising and may be an indication of an appreciation that optimal learning situations is not synonymous with spending time in classrooms and the presence of a teacher.

1.2.1 Constructivism

According to Constructivist theory, learning is a reflective process. By reflecting on our experiences we are constructing new knowledge. Through interaction with the surrounding environment the perception and understanding of the world around us is developed.

> «Constructivism is a process of learning whereby the learner personally constructs and interprets a given set of information based on his or her experiences.» (Kaur A. 2000)

Constructivist theory is represented by two slightly different schools. The Swiss Psychologist J. Piaget and the Russian Psychologist L. Vygotsky are considered the founders of modern Constructivism. Between the two, it is common to consider Piaget as the first to introduce the principles of Constructivism.

Grabingar et.al characterizes Constructivism by three different aspects.
According to the first, learning is an active and evolving process in which the learner attempts to make sense of the world. Based on this, knowledge cannot be acquired by the learner as a well-defined product

> «knowledge of the world is not absorbed, but actively processed by the learner, emerging in the form of mental models.» (Szabo 1998)

According to the second, knowledge is constructed and developed in an authentic learning environment where context is significant in the building of knowledge.
Thirdly, the social context in which the learning takes place is of great importance to conceptual development and takes place by sharing and testing ideas with others.

> «The pedagogy of constructivism includes learning by doing, learning through interaction, learning in rich environments, learning at higher order thinking levels and learning in a teacher-supported environment.» (Kaur A. 2000)

The term rich environments used here relates to situations were the learners can apply and try out their knowledge. According to Brown, Collins and Duguid (1998) and Kaur A (2000) the design of rich learning environments is one of several prerequisites for efficient constructivist learning. Designing rich learning activities is required due to the fact that students are frequently suffering from the «inert knowledge syndrome», that is knowledge learned but not applied in everyday life.

> «What students learn should not be separated from how they learn it.» (Brown et al. (1998) and Kaur (2000)

The term «Learning by doing» was introduced by John Dewey (1910) who rejected authoritarian teaching methods, and viewed learning as a process of inquiry. Children should learn by doing and not be passive receivers of knowledge with issues defined by the teacher. Later, Bruner emphasized that learning is an active process and advocated the use of discovery learning.

> «In its purest form, discovery learning allows the learner a free choice of how and what is to be learned. At a moderate level, discovery learning permits experimentation, whereby the teacher intervenes in the form of coaching, providing learning clues and creating a learning framework for the student. In a purely prescriptive perspective, the

> learner discovers completely what the teacher wants him to discover.» (Kaur A. 2000)

Piaget’s theories are denoted socio-cognitive theories of learning, and centered on development through different stages of the learning process of children. Children develop through a gradual process of interaction with the environment. Faced with new and unfamiliar situations that don’t fit with their existing view of the world, development occurs. In this situation

> «a disequilibria occurs which the child seeks to resolve through one of two processes of adaptation. The child either fits the new experiences into his or her existing view of the world (assimilation) or changes the cognitive structure to incorporate the new experiences (accommodation). Based on the Piagetian principle, it is important that the child be exposed to a variety of learning activities.» (Kaur A. 2000)

According to Illeris, 1974 referred in Fjuk, 1998 the assimilative part of Piaget’s learning theories is described as «traditional school teaching» but accommodative learning has a deeper and more fundamental effect on the learner.

> «Accommodative learning is a learning style, in which an individual’s cognitive structures are changed through disintegration, when existing learning elements are released from the original learning context and can be included in new structures.» (Illeris 1974, Birknes and Fjuk, 1994 referred in Fjuk 1998)

Piaget's cognitive theories where further developed by Papert (1980). Papert claimed that learners should get opportunities to test hypotheses about the challenges they encounter. Although Piaget is regarded as the founder of Constructivism his work and theories are criticized for focusing too much on learning as an individual process and less on intersubjectivity and culture.

> «Piaget underestimated, to a considerably degree, the new born child’s ability to take part in the fine graded cooperation with others. On this point he is fundamentally mistaken.» (Aukrust Grøver V. 1996)

With respect to the lack of focus on cultural factors in children’s development process, Piaget is also criticized for failing in his inductive reasoning and conclusions. His research is based on the study of children in Geneva, Switzerland, and thus getting research results of limited validity in other cultures. This critique of Piaget’s research and theories is one of the reasons for a shift of attention from Piaget to Vygotsky during the past decades. Vygotsky lived and worked in the old Soviet Union, simultaneously but isolated from Piaget, but their theories have much in common. Vygotsky's theories are denoted as social-cultural theories of learning and differs from Piaget’s theories by focusing more on the social-cultural perspective of learning. Vygotsky was strongly concerned with the relations between cognitive development and social development and the cultural environment of the learner.

According to Vygotsky, learning takes place at two levels: the interphsychological and the intraphsychological level. At the interphsycological level, the interaction children have with adults and other children is essential to their construction of knowledge. One of Vygotsky’s most important conclusions is that the development potential of learners are determined by what the learner can accomplish on his own and in addition, what the learner can accomplish in an environment with help available from other and more experienced persons, such as a teacher, peers or tutor.

> «This notion of cognitive growth is related to what Vygotsky terms as the Zone of proximal development (ZPD), which is defined as “the distance between actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more knowledgeable others.» (Vygotsky L. 1978)

> «The gap between actual and potential ability can be bridged through what is metaphorically known as the “Scaffolding process.» (Bruner, Ross 1976)

> «A more experienced partner (peer or teacher) is able to provide scaffolds to support the student’s evolving understanding of the subject matter at hand.» (Kaur A. 2000)

ZPD is representing the learners potential for acquiring new knowledge, a potential that only can be fully utilized when learning is collaborative. The constructivist theory of Vygotsky emphasizes in particular the effect of language and communication in the learning process which is of particular importance for the design of learning environments (Vygotsky 1934. Thought and Language).

> «Vygotsky's revolutionary idea is that thinking and language constitute one unit, and that this unit is the result of human development. Language expressed thinking, and thinking takes place with the help of language, and therefore the thinking and language must be studied simultaneously, as language based thinking.» (Skodvin A. 2001)

The challenges involved in designing learning environments based on these theories is to combine the structuring of the learning processes with large degree of freedom for the learners to search for new solutions and take responsibility for own learning. And it is obviously important to create environments or metaphorically speaking, arenas for communication and peer and expert interaction for the learner.

1.2.2 Behaviorism

The theory of Behaviorism is briefly elaborated in this report despite the fact that the learning processes used for experimentation in the PedTek project are based on Constructivist theories of learning. The main reason for introducing behaviorism in this report is that, as mentioned previously, it can and should be questioned if there, unconditionally exist, any «the correct theory of learning». Designing learning environments to operate under a variety of conditions with different type of users and cultures, may require that we make use of and apply principles from a wide range of the learning theoretical spectrum, spanning from Constructivism in one end to Behaviorism in the other. Knowledge of the basic principles of Behaviorism can therefore inspire to look for alternative solutions.

Behaviorism defines learning as the adaptation of new behavior. People learn or develop new behavior as a reaction to external stimuli. It is claimed that the Behaviorist theory regard humans as preprogrammed to always react in certain ways on certain stimuli. For the practical application of behaviorist theory the reinforced response is of special significance. By encouraging or reinforcing certain responses the probability that this response will be repeated as a result of a certain external stimuli in the future is increased. Based on this, the design of Behaviorist learning processes is concerned with applying stimulation to obtain a desired behavior combined with the reinforcement of desired behavior by encouragement. Correspondingly, negative sanctions or even punishment can be used to prevent undesirable behavior. The American Psychologist J. B. Watson is considered to be the founder of Behaviorism but the research and experiments conducted by the Russian Psychologist Pavlov and the American Psychologist Skinner is best known. Both Pavlov and Skinner conducted experiments with animals and the theories of Conditional behavior and the Skinner Box are important parts of the Behaviorist terminology.

Apparently, Behaviorism and Constructivism represent two diametrically opposite theories of learning. However, both theories are describing learning processes and the learner's dependence on feedback from the surrounding environment is in both cases important issues.

> «we can never get away from the fact that learning programs, all the time, provides some sort of feedback, and that this feedback, depending on the form, can have positive or negative effects on the learner or student.» (Kure B. 1998)

It is difficult to imagine a learning process where the effect of feedback, negative or positive, is of no interest.

1.2.3 PBL (Problem Based Learning)

Among educational institutions, particularly in the field of medicine and health care in Europe, Problem Based Learning has been extensively and successfully applied for many years.

> «Problem-Based Learning (PBL) is a curricular reform that was first introduced with the founding of the Faculty of the Health Sciences at McMaster University in the late 1960s.» (Spaulding 1996)

And it seems to be a tendency that applying PBL «inspired» approached is spreading. Choosing to characterize PBL as a theory of learning is perhaps stretching definitions a little too far, but in the context of the present report this is not a significant issue. It is most correct to denote PBL as a pedagogical approach based on principles from basic Constructivist theory.

> «Design of practical pedagogical solutions based on Constructivist theory should be based on guidelines given by Collaborative and Problem Based Learning.» (G. Bjørke 1996)

For practical applications, pedagogical approaches based on PBL differs and varies from using PBL in its purest form to approaches where PBL principles are hardly detectable. In order to avoid complex discussions and argumentations to justify whether a particular approach is «real PBL» or not, the term POB (Problem Oriented Learning) is frequently used as a substitute.

In its purest form it is required that PBL based pedagogical approaches are organized in specific ways to comply with distinct steps. According to Gerd Bjørke, problem based learning can be described in the following way:

> «A small group of students work with tasks consisting of description of a problem, phenomena or activities from real life which requires an explanation. The descriptions are usually based on situations from working life. The group discusses the problem, tries out different explanations, describes fundamental processes, principles or mechanisms, and formulates their own learning requirements, which is the point of departure of individual studies. Finally the group come together and discus explanations and their understanding of the problem, based on a new platform of understanding.» (Authors translation from Bjørke G. 1996)

The main steps of a pedagogical approach, based on PBL are according to Bjørke G. 1996:

1. Problem understanding
2. Problem definition
3. Analysis
4. Structuring the explanations
5. Identification of learning requirements
6. Knowledge accumulation
7. Synthesizing of knowledge

1.2.4 Collaborative learning and computer support

During the recent years, collaborative learning (CL), has received increased attention as a pedagogical methodology, suitable for applications in technological supported learning environments. But as a learning theory or pedagogical methodology CL also stand on its own, but a strict definition is to a large degree absent and it is easier to start with stating what Collaboration not is:

> «Learning based on a transmissive or information-processing model of education, where the main learning activity is the individual reception and organization of information from books, lectures, videos or computer-based training materials, <u>is not</u> collaborative.» (Antony R. Kaye, 1991)

And it is also apparent that working according to the principles of CL is more common in working life situations not involving formal education programs.

> «One reason why collaborative learning appears to be more common-place in the work environment than in many parts of the formal education system may be because, in our culture, the latter is mainly based on recognition of individual achievements within an essentially competitive environment (collaboration between schoolchildren, in certain circumstances, is still sometimes labeled as «cheating». Another reason might be that the formal education system assigns relatively hermetic roles to participants (one is either a student, or a teacher), and these roles imply an unequal relationship based on differential levels of authority and power.» (Antony R. Kaye, 1991)

Some attempts to define CL can be referred:

> «Collaborate (co-labore) means to work together, which implies a concept of shared goals, and an explicit intention to add value – to create something new or different through the collaboration, as opposed to simply exchanging information or passing on instructions.» (Antony R. Kaye, 1991)
>
> «Successful collaboration assumes some agreement on common goals and values, and the pooling of individual competencies for the benefit of the group or community as a whole.» (Antony R. Kaye, 1991)

In her PhD thesis Abtar Kaur, at the University of Malaysia, is making a distinction between collaboration and cooperation

> «Cooperative learning:
> Groups of students working together to attain a predetermined group-learning goal
> Collaborative learning:
> A group seeks help from another group with regards to their group goal (peer collaboration) and/or a group seeks help from the teacher or any other expert (teacher-learner collaboration, expert-learner collaboration)» (Abtar Kaur. Phd Thesis 2000)

With the increased actuality of applying computers as a mediating tool in learning situations the term Computer Supported Collaborative learning (CSCL) has been introduced. CSCL is concerned with situations where computers or rather Information and Communication technology (ICT) is used for supporting learning processes based on Collaborative learning. CSCL is hence not concerned with all kinds of situations where ICT is used for supporting learning. During recent years, the increased focus on life long learning and the use of Internet for providing off-campus students with educational programs has raised the question how to apply CSCL in this particular context. This led to the introduction of the concept of Computer support for distributed Collaborative learning (CSdCL). CSdCL was introduced by Annita Fjuk in her Dr. Scient thesis at the University of Oslo (Computer support for Distributed Collaborative Learning. Exploring a Complex problem Area. 1998). The thesis is focusing on collaborative learning situations where the students are individually separated by physical distance. In this respect CSdCL is basically an application of CSCL in situations involving students geographically separated from fellow students, teachers and supervisors. In most respects CSdCL involves the same challenges as with CL and CSCL, but as pointed out by Fjuk (1998), involving distance education students, introduces some additional challenges and problems.

> «These challenges are manifested by critical factors, represented by a tension between Pedagogical, technological and organizational aspects. The pedagogical aspect is connected to theories and methods of learning. The technological aspect is connected to the embedded conditions of the available computer-based recourses. The organizational aspects are related to the institution's educational system and tradition.» (Fjuk A. 1998)

1.3 Activity theory

Activity theory was developed and has evolved as a means of understanding important phenomena in society involving the interaction of and relationship between consciences and activity. It can be argued that Activity theory is not a theory in the strict and scientific meaning of the term, but rather a method or tool, which can provide us with new and interesting perspectives on certain aspects of society. In particular, with the increased integration of people's activities and technology, which has taken place during the last century, the ideas of Activity theory have a correspondingly increased actuality. The theory has its origin in the field of psychology in the old Soviet Union and has been developed and refined during the past 80 years.

> «It is concerned with understanding the relation between consciousness and activity and has labored to provide a framework in which a meaningful unity between the two can be conceived. Activity theory is pertinent to technology design and evaluation.» (Nardi A. 1997)

> «Activity theory is a powerful and clarifying descriptive tool rather than a strong predictive theory. In the context of the increasing degree of computers, interacting with the way we live and engage in activity,

> Activity theory has experienced a renaissance with the introduction of computers in society and the particular challenges involved in Human Computer Interactions (HCI).» (Nardi A. 1997)

With the increased application of modern technological artifacts in educational systems, such as the Internet, Activity theory represents means of understanding the phenomena involved. The theory can contribute to this understanding, first of all, by widening our horizon, ensuring that the common mistake of over-focusing on technology is avoided. In relation to phenomena concerned with HCI in educational systems and in particular computer support of Constructivist based learning processes, activity theory as a tool has a potential for explaining and understanding what we observe. The connection between consciences and activity is closely related to the enhancement of knowledge and our interaction with a surrounding environment. According to the constructivist theories of Vygotsky there is a correspondingly strong relationship between thinking and language, making Activity theory applicable for analyzing educational phenomena.

> «Vygotsky described consciousness as a phenomenon that unifies attention, intention, memory, reasoning, and speech.» (Vygotsky 1925/1982; see Bakhurst 1991)

By considering what constitutes an activity we find that in some way or another, technology in a broad sense of the definition, is always involved in an activity. The involvement of technology is present, in most cases, as some way of mediating information and hence part of a learning process, even if this in many cases may have a short duration.

> «An activity always contains various artifacts (e.g., instruments, signs, procedures, machines, methods, laws, forms of work organization). An essential feature of these artifacts is that they have a mediating role. Relations between elements of an activity are not direct but mediated; for example, an instrument mediates between an actor and the object of doing; the object is seen and manipulated not «as such» but within the limitations set by the instrument.» (Engeström 1991)

How we deal with and handle our interaction with technology and especially how to resist a deterministic attitude towards technology is a particularly important issue to day. By regarding technological development as processes determined by a kind of «law of nature» we are pacified and more prepared to accept technological design and functionality as something «we have to live with».

> «Artifacts themselves have been created and transformed during the development of the activity itself and carry with them a particular culture – a historical residue of that development. Because of the nature of artifacts, they should be never treated as given. The idea is that humans can control their own behavior-not 'from the inside', on the basis of biological urges, but 'from the outside', using and creating artifacts.» (Kuutti K. 1997)

As the case is with most theories and tools, they provide us with some, but not sufficient means of understanding phenomena and accomplishing tasks (the availability of a sewing machine does not make us a competent tailor). The gap between availability and ability to achieve practical usage is often large and hard to span. Emphasizing this is important to avoid the pitfall of believing that Activity theory represents a well structured methodology, which when applied, ensures a perfect harmony when designing systems where people interacts with technology. The reason for introducing the ideas of Activity theory in this report is merely to ease the understanding of the reasoning and conclusions with respect computer interaction in the context of learning. With the experimental development process, testing prototypes, applied in the PedTek project this is particularly relevant.

> «This approach to design is interactive. I seek to inform the design of technology by studying the use of initial prototypes in realistic situations.» (Bellamy R. K. E. 1996)

> «The essence of Activity theory is that it consider peoples interaction with computers as a wide spanning phenomena.» (Kaptelinen V. 1996)
> «Activity theory can inform our thinking about the process of designing educational technology to effect educational reform. In particular, through emphasis on activity, it becomes clear that

technology can not be designed in isolation of considerations of the community, the rules, and the division of labor in which the technology will be placed.» (Bellamy R. K. E. 1996)

2. The Research and Development (R&D) process

2. 1 Theoretical background

The R&D process conducted in the PedTek project represents a comprehensive enterprise, involving numerous considerations and challenges, many of which, not became apparent until the later stages of the process. The original plan, as previously pointed out, was to design and perform experiments with Net Based Learning Environments (NBLEs) prototypes during a period of three years. However, during the course of the R&D process, the learning progression of the researchers accelerated and the rate of acquiring new knowledge increased considerably as the process progressed, thus making it hard to decide when to stop exploring and experimenting and when to present concluding comments. Retrospectively, it can be concluded that a lot should have been done differently. But as a comforting reflection, this is hopefully an indication that our knowledge of the issues involved is enhanced and that the results presented, thereby can contribute to the accumulation of knowledge in the field of designing and implementing Net Based Learning Environments. In view of this, great care is taken in the present chapter, not to cover, but to explicitly expose uncertainties and insufficiencies of the R&D process, even if this reviles embarrassing shortcomings of the research conducted. With this approach, discussing and exposing uncertainties, it is believed that a better foundation for further research is provided, by improving the chances of avoiding the same pitfalls. With the dual, but interrelated goals of the action research oriented PedTek project, exposing weaknesses and shortcomings of the R&D process is particularly significant. The main goal of the development process was to design and implement efficient NBLEs of high quality whilst a major goal of the research activity was to evaluate the success of the same NBLEs. The developers success will then be determined by the results from the evaluation of the NBLEs performance whilst the researchers will pursue a critical approach, ideally attempting to objectively describe the performance of the same NBLEs. With the same persons, having the roles as both developers and critical researchers, the quest for the R&D goals represents a potential conflict of interest and requires a high degree of professional integrity.

> «Researchers should be explicit about their approach, clarifying their research aims, theory, and method at the outset and all the way through its application, as well as at the time of its publication.» (Avison D. et al 1999)

However, the mechanisms involved, with accurate feedback from the research activity being a prerequisite for efficient development, helps, to some extend, to counteract the effect of conflicting roles of researchers and developers. In this context it is in the interest of the developers to get feedback based on a critical analysis. Despite this, the question of neutrality and objectivity of the researchers in these situations is particularly pertinent to ask. And the answer is that in this, and most other situations, the role of the objective and neutral researcher is an illusion.

> «Few to day, will claim that the high ideals of positivism, with objective and theory independent observations is possible. The idea that the «facts speaks for itself» is undoubtedly an illusion, both for daily life matters and in science.» (Sjøberg S. 1981)

Most research activities are effected by the researchers values, motivation and desires and even unconscious agendas. The best solution to this problem is to avoid an approach were neutrality and objectivity is pretended and instead ensuring that the researchers values and interests are known and details, belief and doubts, related to the research are explicitly exposed. The users of the research results will then be in a better position to determine the validity of the research findings.

With the above perspective on the R&D process, the main purpose of the present chapter is to introduce and discuss the rationale of both the development and the research activity. The objective is to provide a best possible background for understanding and interpreting the results presented. It is also important to emphasize that the R&D activity has taken place in a multidisplinary area, combining social sciences and natural sciences. This involves different research traditions and cultures and raises fundamental questions related to the philosophy of science of whether society and social phenomena can be understood in terms of the paradigms of natural science, and if technology can efficiently be developed and implemented based on the approaches advocated by social sciences.

The first part of the present chapter is presenting the theoretical background of the R&D process, the second part is describing the case and the experimental conditions and the third part is presenting results from analysis of the empirical data, attempting descriptive presentations and to avoid normative statements and extensive interpretations. Interpretations, conclusions and normative based reflections are left to chapters later in the report.

2.1.1 Development philosophy

Since the first introduction of computer based information systems in organizations in the early 1960ties, system development has become an increasingly important profession.

> «Systems Development implies to develop, adapt and introduce computer-based systems in organizations.» (Øgrim L. 1993)

Systems development is conducted, as a professional discipline, with the objective of developing general computer based information systems. The various methods recommended and preferred for the development process varies. With the development goal of the PedTek project, the computer based information system to be developed, differ from many other computer based information system in the sense that the functionality and the mediation of the system output requires pedagogical considerations. In this context, the Net Based learning Environment (NBLE) represents the computer based information system. This computer based information system consists of a technological part, an organizational part and a person or user part. The technological part is represented by the Internet and the users PCs, the organizational part by the pedagogical implications of organizing the learning process and the users are the students, teachers, supervisors and mentors. To characterize this type of computer based information system, the term Pedagogical Computer Based Information system is introduced.

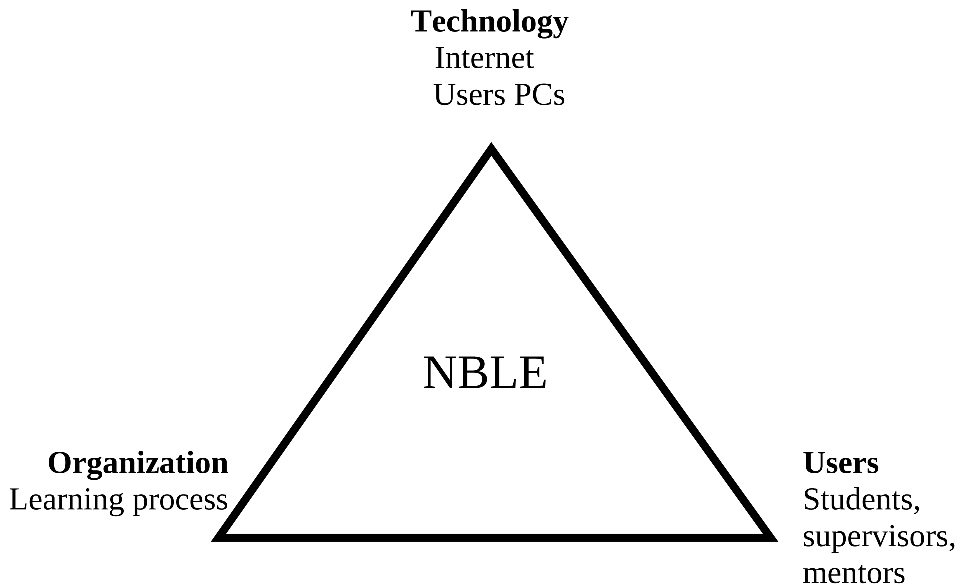


Fig 2.1
NBLE as a Pedagogical-computer-based information system

During the last decades, the field of systems development has matured and evolved into a multidisciplinary area. Experience from the field of systems development indicates that successful implementation of IC technology requires that great care is taken when conducting the systems development process by ensuring a proper understanding of the organizational context of technological systems. Traditionally, systems development is approached according to the Waterfall model. Waterfall is used as a metaphor for a process with few opportunities to turn back and restart the development process. When the development process is started, a user analysis is conducted and a user requirement specification is produced. In order to ensure a well-structured development process, with minimal disturbances, the requirement specification is «frozen» and the process continues until the computer-based information system is implemented in the user organization. This development approach is based on the optimistic and frequently unrealistic assumption that users requirements can be defined at an early stage in the development process. Developing and introducing computer based or net-based learning environments in organizations, involves considerations and situations of which we have little previous experience. The degree of uncertainty is considerable and defining user requirements or predicting development paths with reasonably accuracy is difficult. The system users represented by supervisors, administrative staff and technical support staff are approaching new and unfamiliar working conditions. Technological solutions, in particular Internet-based applications are introduced and changed at a high rate. For these conditions, traditional systems development approaches are less suitable.

> «A theory of management of systems development processes and projects is required, which assumes that the user organization, the technology and the marked is continuously changing and that the members and participants of the project are changing through learning. A theory of this character can not be based on the ideals of technical rationality.» (Øgrim L: 1993)

To resolve problems and challenges related to systems development, approaching new and unfamiliar territory, methods inspired by dialectic theory is recommended.

> «Dialectic is used for studying change, based on the assumption that everything is to be considered as continuously in motion and developing, standstill is considered to only be a temporarily state. Dialectic theory is useful for describing and understanding motion and development.» (Øgrim L. 1993)

Applying an experimental approach in systems development is becoming increasingly more common and implies that the development work is initiated without having defined a comprehensive and final systems requirement specification.

> «Experimental approaches regards systems development as a process of learning in which, the action aspect represents the main part of the contradiction.» (Øgrim L: 1993)

2.1.1.1 Experimental systems development (prototyping)

Experimental systems development is based on a heuristic approach applying a «trial-and-error» or «exploratory» method of problem-solving, taking certain steps toward solution of problems and evaluating results as these steps are completed. Heuristic comes from the Greek word heuriskein, meaning «to find out, to discover», and systems development based on a heuristic approach is very different from a traditional, algorithmic approach, which is precisely defined and structured. With experimental approaches to systems development the processing of results from the prototype testing is a particularly critical issue. Successful experimental development requires empirical material from the prototype testing with high degree of validity and reliability. The objective of processing test results is to provide the developers with information required for improving the systems requirement specification and based on this, redesigning the prototypes during the development process and eventually for designing a final version of the system for a more permanent implementation. The main part of the test results will normally be represented by a positivistic inspired process with emphasis on analyzed and interpreted empirical material from a planed and systematically conducted data collection process. But experimental development processes may also involve considerably explorative elements were the significance of less predictable and more unexpected phenomena observed, must be considered. During the conduction of the experiments and retrospectively the developers may gain enhanced understanding and insight in the problem area as a result of observing and experiencing the occurrence of less predictable phenomena.

> «Experimental approaches assume that organizations are pluralistic and continuously changing. Experiments involving different solutions is required to disclose the user requirements, to test technological solutions and evaluated alternatives in practical environments. Experimental approaches is preferred, based on the understanding that systems development processes not can be pre-planed and controlled in detail. The approach is determined by the actual situation and is action oriented because the structure will be adapted to the progression of the process.» (Øgrim L. 1993)

The overall evaluation of the prototype performance is based on a combination of the empirical material from both the positivistic inspired, systematically planned data collection process and from the comprehension of the developers enhanced understanding and insight obtained by experiencing less predictable phenomena.

With experimental systems development the systems requirements gradually evolve as a result of testing, evaluating and redesigning the prototypes during the development process. Applying experimental approaches is based on many years of experience from systems development, which clearly indicates that with traditional systems development most systems requirements need to be considerably changed during the course of a development project.

> «The user requirements as a basis for the projects could not be described completely. New requirements emerged throughout the projects. As a consequence steps back to the previous development phases had to be taken continuously.» (Kautz. K. 1993)

> «prototyping is a strategy for performing requirements determination wherein user needs are extracted, presented and developed by building a working model of the ultimate system – quickly and in context.» (Boar 1984)

With experimental systems development, an initial analysis is performed and a preliminary systems requirement specification is produced at an early stage in the development process. This specification reflects the developers' insight and understanding at this early stage of what is required of the future system and must be sufficiently detailed to enable the design of a first, testable prototype. However, no exact definition exists of what is sufficient in this context and what qualifies a prototype to be testable. But obviously, the closer the design of the first prototype is to the final version the more efficient is the development process. And further, the term «final version» is not uniquely defined. Qualifying as a final version does not imply that further improvements are not required or will be carried out, but refers to the state of an information system, which is considered to have at least sufficient quality to be implemented and can satisfactorily serve its purpose. With traditional systems development the development process is formally terminated at the end of the project and alterations and systems improvements are considered as part of maintenance or defined as a new project. Experimental systems development is focusing less on the product

> «It understands systems development as a process that does not stop when a development project stops. It comprises development and use.» (Kautz. K. 1993)

2.1.2 Risk handling and ethical considerations

Conducting experiments always involves some degree of uncertainty with respect to the outcome. If this were not the case, it would not be experiments, but ordinary organized activities. In the case of the PedTek experiments, two undergraduate courses, attended by Computer Science students at Hedmark University College was involved. In one sense, the students attending the experimental courses had the role as test objects or «guinea pigs». Failure by the developers to provide satisfactorily learning process could easily cause inconvenience and problems for the students involved. With this in mind when embarking on the experimental process and throughout the project, great care was taken to reduce the type of risks, which could lead to negative effects for the students. If the experiments should prove not to progress according to plans, the project was continuously prepared to engage additional tutorial and teaching resources to compensate for unsatisfactorily learning progress. Under no circumstances should the students have to carry the burden of failure in the design, organizing or implementation of the NBLE prototypes.

Involving real people in the experiments also introduced ethical issues with respect to how and which solutions could be tested. From a «pure» research point of view it would have been efficient and desirable to test different solutions on different groups of students in order to obtain variations in the experiments. It would however be ethical unacceptable to plan and try out assumingly inferior solutions with some students and assumingly superior solutions with other students for the sake of obtaining variations in the experimental conditions.

> «Action research aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social

> science by joint collaboration within a mutually acceptable ethical framework.» (Rapoport, 1970)

The ethical considerations, thus restricted the experimentation by not allowing tests of many types of alternative solutions.

2.1.3 Research philosophy

The research process conducted in the PedTek project had dual but closely related objectives. One was to continuously acquire knowledge, providing feedback to the experimental development process, enabling redesign and testing of the prototypes. The other was to explore and enhance our general knowledge of learning processes applying NBLEs, in particular with solutions based on PBL and collaborative learning. Complying with the requirements of these research objectives required somewhat different research strategies, but the overall research approach qualifies to be characterized as a type of Action research.

> «with action research we mean roughly any activity which is pursuing two goals. One goal is oriented towards practical activity in society (action), and the other is oriented towards a systematic way of understanding reality, through evaluation of the action or in other ways (research).» (Axelsen T., Finset A. 1973)

With the R&D approach of the PedTek project the «D» represents the action and the «R» represents the research activity. When emphasizing the dual objectives of the research in the PedTek project it does not imply that this is in conflict with the principles of Action research. It is however, necessary to make it clear that part of the research activity in PedTek goes beyond what is strictly required for supplying the ongoing development process with required feedback. The none-feedback oriented research was conducted to enhance the general knowledge of NBLE applications and was pursuing an explorative approach. The feedback-oriented research differs from the none-feedback oriented approach in the sense that it is related to some predefined success criteria. Conducting experiments and redesigning solutions based on research results requires predefined goals. Conducting experiments and explore, in order to gain general knowledge does not, by definition, involve predefined goals or success criteria.

> «Two categories of action research can be identified. One implies that the researcher's actions are based on his results. The researcher is first conducting the research and then initiates the action. The other category implies that the researcher initiates an experiment and simultaneously follows this up as a researcher.» (Axelsen T., Finset A. 1973)

With this point of departure, planning and conducting the PedTek research involved many complex considerations and conflicting decisions. In some respect, it can be argued that the experimental design, involving technology, students and course programs, closely resembles a laboratory situation, inspired by research traditions of the natural sciences. To the extent this is so, the approach can be criticized for attempting to apply methodology from the natural sciences on domains of the social sciences. The crucial point in this context, and the question of the justifiability of the critique, is firstly whether better, practical alternatives exist, and secondly, how the empirical data was collected, analyzed and interpreted. No simple and precise answers to these questions can be provided. However, the purpose of explicitly elaborating these issues here is to emphasize that the research was conducted with these problems on the agenda. The particular research approach of PedTek was chosen and pursued, with the consciousness that the nature of the project was interdisciplinary and sought to draw on the best from several research traditions and cultures. By doing this, the risk of «falling between two chairs» was obviously present and hence producing results, not satisfactorily for the scrutiny of any traditional research community.

The main reason for applying a research approach, more inspired by natural science research traditions than what is normally done in comparably studies, is the absence of better alternatives. Well aware that natural science inspired research have shortcomings, in particular when it comes to contextual interpretations, involving people and social systems, it also have strong sides when it comes to other issues such as preciseness of analysis and conclusions. Many projects, comparable with the PedTek project, are suffering from a failure to draw sufficiently precise conclusions, not enabling suggestions and conclusions of how to implement improved solutions. They present interesting critique of existing systems and solutions, but faced with the task of designing and implementing new versions, a relatively precise requirement specification, even if it is preliminary, is required.

The most common critique against applying a natural science inspired approach to research involving social issues is that it is based on the affirmations of Positivism that all knowledge regarding matters of fact is based on the «positive» data of experience. This view assumes that neutral, value independent and objective observations are possible. This critique is also a core issue in the Positivism debate, which was initiated a few decades ago and still is going on, even if the intensity of the debate has considerably decreased. The critique is undoubtedly, to a considerably degree justified and is considered as a major factor, contributing to the popularity of Action research approaches. Being conscious of the possible pitfalls of attempting neutral observations has been a major concern of the PedTek project. Balancing the need for precise information with initiatives to avoid laboratory like conditions has represented a considerably challenge throughout the project.

> «The effects of distributed and computer-mediated collaborative learning interactional processes then, I argue, are sought to be understood through participant observation and through collaboration with those involved: The students, the teachers and the CSdCL organizers. Hence, I argue that positivist research approaches imply shortcomings with respect to the problem area.» (Fjuk A. 1998)

With the constraints given by the above arguments, it was never the less necessary to establish success criteria, represented by measurable variables, in order to achieve a satisfactory progression in the experimentation. The definitions and opertionalization of the phenomena, representing success criteria are discussed in the next part of this chapter. But simultaneously it has to be accepted that some analysis and interpretations goes beyond formal methodology.

> «We live in a age that celebrates technique. This is particularly evident in the social sciences, where concern for methodology dominates. While methodological sophistication provides an important basis for the technical conduct of research, this is insufficient to establish a

> social science that is substantially rational in the sense that its practitioners are able to observe and question what they are doing and why they are doing it, and thus to make informed choices about the means and consequences of their research. For this, a much broader and self-reflective stance is required. A knowledge of technique needs to be complemented by an appreciation of the nature of research as a distinctively human process through which researchers *make* knowledge.» (Morgan Gareth 1983)

But, going beyond formal methodology does not imply that all conclusions based on «pure intuition» or the «belly feeling» is acceptable, at least if we want to remain inside the frameworks of science.

By restricting analysis and conclusions to what is based on well-documented observations through established methodology, we are on the safe side, but are running a risk of excluding and sacrificing important information. In some cases and situations we know «the truth» but are unable to «prove» the existence of this knowledge. In most practical daily life situations the feeling itself is sufficient and we don’t have to provide proofs. We may know that we are happy, sad, living a good life or are in love and that is, in most cases very reliable and sufficient. Similarly, we may have the feeling that for example certain learning processes are going well, and with long experience as teachers or lecturers, this feeling should be taken seriously, even if we are unable to bring forward clear evidences and prove that this is the case. And being in the business of science and research we are then faced with the dilemma of restricting our self to the provable conclusions and excluding important parts of reality or choosing to include the more «obscure» and less provable parts and being accused for not complying with the rules and regulations of science.

These types of questions have occupied philosophers for long times but remains to be completely resolved. Recently, the British philosopher Gilbert Ryle (1950) elaborated on the phrases «know that» and «know how». He argued that «know how» is normally used to refer to a kind of skill that a person has, such as knowing how to swim. One could have such knowledge without being able to explain to someone else what it is that one knows in such a case, that is, without being able to convey to another the knowledge required for that person to develop the same skill. However, to probe deeper into the epistemological nature of this problem area is clearly beyond the scope of this report.

The approach to these complex issues in the present report is to include many of the more speculative interpretations and conclusions, but simultaneously exposing and making the uncertainties explicit. Thus, providing insight and background, enabling the readers to draw their own conclusions and make their own interpretations.

2.1.4 Evaluation methodology

The methodology applied in PedTek for retrieving information about the experiments conducted can be divided into the following five categories.

1. Interviews
2. Questionnaire surveys
3. Participant observations
4. Secondary sources
5. Intuition based conclusions

To varying degrees, each category has contributed to the empirical material, which is the basis for the conclusions, interpretations and recommendations made in this report. The fifth category, intuition, is included to cater for and justify conclusions, which goes beyond formal methodology which was elaborated above in the discussion of the research philosophy. The empirical material collected by means of the five different data collection methods consists of both quantitative and qualitative data.

Throughout the experimentation extensive interviews where conducted with students, administrative staff at Hedmark University College and persons supervising the students during their learning processes. What is termed interviews in this context is not restricted to planed meetings, but also includes less formal conversations, and as such the interviews are frequently overlapping with what can be characterized as participant observations. During and at the end of each concluded learning process the students were asked to fill in a questionnaire. This was in most cases presented to the students during a mandatory gathering, in a different course, thus ensuring a high percentage of feedback from the students involved in the experimentation. A questionnaire was also sent to an arbitrary selected group of postgraduate students who were in a position to evaluate the usefulness of the experimental courses with respect to their work life experience. As mentioned above, participant observations are to some extend overlapping with informal interviews. But participant observations also include the information we gained from cooperating with the students on campus, either in direct connection with the experimental courses, or when involved in discussions on other issues. From a researcher's point of view, the opportunity to «mix» with the research objects, the students, in natural ways has been a great advantage. The use of secondary sources of information mainly includes contact with other researchers at other institutions preoccupied with similar issues and experiments.

With respect to the validity and reliability of the empirical data it can be concluded that they are at least satisfactorily and holds an acceptable standard. However, some uncertainties are involved with respect to the validity due to what is commonly denoted as the «Hawthorne effect». This term originates from the experience gained by the Human Relation school in the 1950ties and 60ties when experiments were carried out in the workplace with the purpose of understanding and improving work environments in factories in the UK. These experiments drew attention to the fact that attention from the researchers in it self had positive effects on the work environment, regardless of the more objective working conditions. By conducting experiments, involving students on the campus, it should be taken into account that the «Hawthorne effect» also may have been present, and effected the feedback from the students during the PedTek experiments. However, it is difficult to conclude to what extent this effect is significant, and further it may have had both positive and negative effects on the students' attitude. By being aware that they were in focus of the researchers, whom they also knew and therefore felt relatively free to confront with critical opinions, they may have both exaggerated and minimized the problems in order to either protest against or please the members of faculty.

With the applications of the different methodologies for evaluation it has been attempted to have a reasonably clear conceptional model of what constitutes «good» and «bad» results or high and low quality in mind. Both when designing questionnaires, planning and conducting interviews, having informal talks and reflecting on phenomena observed, a «kind of» conceptual model has been more or less in the back of the researchers minds. In the aftermath of a meeting with the students, a net-based tutorial session or having evaluated student reports the questions: How are the students doing? And, are we providing them with good learning conditions? have been asked. And as an effort to systemize and understand what we have observed and experienced the conceptual model of success criteria has been a useful reference. This model is further described and discussed in the next part of this chapter.

2.1.5 Success criteria

The R&D process conducted in the PedTek project is represented by two sub processes. The first is the development process and the second is the research process consisting of a feedback oriented part and an explorative part. The success criteria presented and discussed in this chapter refer mainly to what is relevant for the development process. The objective of the research activity was: *«continuously acquire knowledge as feedback in support of the development process and to gain general knowledge in the field of NBLE.»*

Success criteria for the feedback-focused part of the research are largely determined by to what extend it serves the purpose of providing feedback and thus, closely related to the goals of the development process. The success criteria for the explorative research activity is simply, to the extend it has contributed to the enhancement of knowledge related to the use of NBLEs.

Developing and testing any process, system or product requires a definition of what constitutes successful solutions. It must be possible to identify and differentiate between solutions of varying quality. Absence of such definitions leaves the developers with no means to maneuver. It becomes impossible to evaluate the experiments and consequently, the developers are without a background for drawing conclusions and suggesting improvements. The more accurate the phenomena of quality is defined and operationalized the better is the maneuverability and the more efficient and focused the development process can be conducted.

The overall goal of the development process was defined to be:
«Design an efficient and flexible Net Based Learning Environment (NBLE) for off-campus students, applying pedagogical principles based on Collaborative Learning (CL) in combination with Problem Based Learning (PBL).»

The success of the development project is hence determined by the degree to which these pre defined goals are reached. A development result represented by a highly efficient NBLE, based on pedagogical principles from CL and PBL, allowing very flexible learning processes and fully complying with the requirements of off-campus students, can be characterized as a very successful outcome of the development process. But, even if the above reasoning is logically sound, it comes close to a tautology. It contributes with little more information than concluding that a development process is successful when it reaches its goals. In order to conduct experiments, the success criteria must be converted to operationalized phenomena, represented by qualitively or quantitatively measurable variables.

The following four phenomena are used as indicators of the successfulness of the development process according to the goal definition:

1. Learning outcome
2. Flexibility of the learning processes
3. Resource requirements
4. Learner's satisfaction

The phenomena, «Learning outcome» refers here, mainly to the knowledge enhancement the students have experienced by attending a particular course or learning process, according to a predefined curriculum and other formal learning goals, but not unconditionally. It assumes that the learners have certain initial skills when embarking on the learning process, and hence, learning outcome is not a purely, relative term. Attending a certain learning process, a priory, skilled student is expected to end up at a higher «knowledge level» than an initially less skilled student. In addition to knowledge enhancement related to a pre-defined curriculum, learning outcome also includes, to some extend, enhancement of the students ability to work independently and take responsibility for own learning. However, the definition of the phenomena, learning outcome used here is controversial and do not include other and admittedly equally important effects of being a student, such as skills in socialization, tolerance etc. The exclusion of these factors clearly represents a less satisfactorily part of the definition of the phenomena, learning outcome, and correspondingly reduces some of the value of the experimentation. It is, however, clear indications that even with the above limitations of the definition of Learning outcome, many educational programs would benefit from improving the learning outcome.

> «Education should produce individuals who have a sound working knowledge base, who can use that knowledge when called upon to do so, and who are willing and able to continue the learning process after schooling. There has been increasing concern about the ability of the American education system, elementary through postgraduate, to produce such individuals.» (GPEP, 1984; National Commission on Excellence in Education, 1983; National science foundation, 1982. in Koschmann T. 1996)

The choice of limiting the definition of learning outcome to the above is based on practical considerations with respect to the recourse framework of the PedTek project. A comprehensive definition of learning outcome also involves theoretical difficulties and attempts to produce measurable definitions of the phenomena are approached in different ways. In her research with learners in Malaysia, Abtar Kaur used <u>enhancement of higher order thinking skills</u> as a reference for the quality of the learning process to be tried out.

> «Higher order thinking skills in the current study includes the skills to analyze, mainly by extracting main points as well as comparing and contrasting; the skills to synthesize, that is by summarizing and paraphrasing information; and the ability to evaluate, mainly by giving valued judgments. … higher-order thinking also includes standardized thinking skills such as classification skills, that is the ability of learners to recognize similar patterns in concepts and classify them ….» (Kaur A. Design and Evaluation of a Web-based Constructivist Learning Environment for Primary school students).

With the above definitions, evaluating the learning outcome of particular learning processes may be relatively precise, but for practical applications the disadvantage is that both pre learning process and a post learning process tests of the students are required, in order to determine the relative enhancement of higher order thinking skills. In further research a more comprehensive definition of the phenomena, learning outcome should be adapted and care taken to determine the students «skill levels» before and after the experiments are conducted.

The phenomena «Flexibility of the learning processes» refers to the degree of freedom the students have to choose when and where to conduct their studies. This freedom is crucial for many off-campus students, engaged in learning programs, as part of a life long learning process where they are combining studies with jobs and family obligations.

The phenomena «Resource requirements» refers to what is required of resources, both by the students and the educational institution, for delivering a course using NBLEs. For most practical applications, a measure of NBLE performance has little meaning without considering the amount of resources required to achieve a certain quality. With unlimited resources, learning environments of high quality can be relatively easily realized, but may be commercially and practically useless. The resource requirements represent a measure of the total consumption of human, economical and technological resources involved in conducting a particular NBLE-based learning process.

The phenomena «Learner's satisfaction» refers to how pleased and satisfied the students are with the learning conditions provided. Learner's satisfaction is strictly not a success phenomenon since it is not a goal in it self to please the students. It can clearly be argued that a learning process is successful if the students have gained large amount of knowledge even if they are not happy about the way this is achieved. However the phenomena is included for two main reasons. Firstly, it is reason to believe that happy and content students are more motivated and hence will put more effort into the learning process and consequently learn more. And secondly, practical considerations, related to the usefulness of any educational solution, indicates that the students must, to a certain degree enjoy the learning process, otherwise, most educational institutions will not, in the long run, be competitive in the student's marked. The exception may be some elite institutions, which for different reasons have advantages, compensation for learners' satisfaction. But these institutions are exceptions and self-sufficient and do not need to be very concerned with students' satisfaction. In this sense the phenomena «Learner's satisfaction» is both a means and a goal.

With the above definitions of the four phenomena, representing success criteria, the following table indicates, in a simplified way, what is considered to be successful and unsuccessful solutions.

Quality of solutions / Success Phenomena	Successful solutions	Unsuccessful solutions
Learning outcome	High	Low
Flexibility	High	Low
Recourse requirements	Low	High
Learner satisfaction	High	Low

Table 2.2
Success phenomena and quality of NBLE solutions

Table 2.2 indicates roughly what can be defined as successful and unsuccessful NBLE solutions. When the students attending a course, are experiencing a high learning outcome, have a highly flexible learning situation, and the learning processes can be run at a «low cost» and the students are satisfied, the solution can in most cases be considered as successful. However it must be emphasized that this is generally, only applicable for relatively traditional college educational programs and students. Under different conditions and circumstances it may be more correct to weigh the phenomena differently in order to achieve success. One example may be that the learners are in a situation where it is of great importance to acquire some limited knowledge about a particular issue and hence that the learning outcome do not have to be very high. And if the same learners, for whatever reason, are unable to comply with normal requirements with respect to traveling or availability of technical equipment it may be acceptable to run the course at high costs. In these situations a solution may be successful even if it «scores» low on learning outcome and high on resource requirements.

When applying the four phenomena as criteria, determining the success of prototypes tested during experimental development processes, they must be operationalized and represented by measurable variables.

> «Operational definition means to define which operation which have to be conducted in order to identify a real phenomena.» (Hellevik O. 1979)

> «…operationalization, a term that originally derives from physics to refer to the operations by which a concept (such as temperature or velocity) is measured.» (Bridgeman 1927)

The definition and presentation of any kind of success criteria must be related to some goal or objective of the activity. Without any goal or objective it is impossible to judge whether the activity is successful or not. In many situations, with different categories of activities, it is difficult or even impossible to define clear and well-defined goals or objectives, at least prior to the start of the activity. The nature of many research activities belongs to this category and particularly to research characterized as «explorative».

> «when a satisfactorily conceptual framework is missing, an explorative approach is frequently an alternative.» (Hellevik. O. 1980)

With explorative research the objective or goal is to gain more knowledge in a certain area and the success will then be determined by the amount of new and interesting knowledge is acquired through the research activity. What kind of knowledge, which is considered interesting, can often not be defined before the new knowledge is available. With some of the research in PedTek this was the case and consequently the presentation of well-defined, comprehensive, success criteria is absent. How successful the research activity in PedTek has been will largely have to be determined by the research community in general and in particular the part of the research community concerned with on-line learning issues. The closest we can get to define specific success criteria for the research in PedTek is how beneficial the research has been with respect to supplying the experimental development process with feedback. And the judgment of this success will have to be related to the success of the development activity. The part of the successfulness of the solutions, related to the organizing and delivery, is implicitly included in the discussion and comments related to each success criteria.

2.1.5.1 Learning outcome

Based on the definition of the phenomena, «Learning outcome» given above, operationalization of the phenomena requires definitions and understanding of what is to be meant by «knowledge according to a predefined curriculum» and «other formal learning goals». Applying the phenomena, Learning outcome, as a success criteria, in the testing of learning processes, requires further that the phenomena, in some way, can be represented and explained by variables, measurable or enlighten by the use of quantitative or qualitative data.

With reasonable degree of precision the phenomena «Learning outcome» can be described in the following way:
To what extend the students, having followed a particular learning process

- have theoretical knowledge and understanding of the predetermined curriculum.
- are able to apply the theoretical knowledge in practical situations.
- are able to work independently and collaboratively, and when required, able to acquire necessary knowledge and information, in addition to the curriculum.

Based on this description of Learning outcome, a operationalized definition of the phenomena can be:

- Registering the marks and formal evaluation results obtained at exams and present in the students' «portfolios».
- Registering the students own opinions and attitudes about their subjectively experience of the value and usefulness of what they have learned.
- Registering the knowledge and skills with reference to particular issues, demonstrated by the students when participating in the general academic activities.
- Registering the students' ability to work independently and collaboratively.

Groups of variables, representing the phenomena, Learning outcome, can then be presented by the following:

- Exam results represented by marks
- Portfolio content, represented by comments from supervisor and marks
- Students’ opinions and attitudes
- The knowledge and skills demonstrated by students
- Collaboration and independent work ability

Measuring and determining «values» of these variables require the investigation of exam results, contents of portfolio journals, observation of the students when engaged in on-course and off-course academic activities, conducting formal interviews with students and retrieving information from questionnaire based surveys.

With the experiments conducted in PedTek, involving students attending courses in Project Management and Systems Development, the variables applied are specifically related to these issues. For the students attending the Project Management course, special attention is paid to their knowledge and skills related to project work. In particular, their performance in conducting their final year project in the period following attendance of the Project Management course is relevant. However, a precise determination of the enhancement of knowledge and skills in Project Management, ideally requires detailed and comprehensive information of each student before and after the NBLE based learning process. Accurate assessments, require that effects of the NBLE, on the phenomena Learning outcome, are isolated from the contribution from other sources that may effect the enhancement of knowledge and skills among the students. The investigation and use of exam results in this context, refers to the specific and concrete results obtained and a comparative study of these results and the results obtained by previous students, having attended a traditional lecture based course, using the same curriculum.

2.1.5.2 Flexibility

Achieving flexibility in the learning process represents a paramount goal of the development work. Low flexibility would make the solutions unsuited for off-campus students. With the phenomena «Flexibility of the learning processes»

defined as the degree of freedom the students have to choose when and where to conduct their studies a more precise definition is:
To what extend the students, having followed a particular learning process

- have to be present at a specified location at a certain time in order to conduct their studying.

An operationalized definition of this phenomena will be based on a combination of what the students, involved in the learning process, feels and expresses about the freedom to conduct their studies related to their job and private life obligations. In addition a more objective definition is based on a comparison of the present situation and present requirements with the situation in a traditionally, lecture based learning process. A phenomena with this definition, can to some extend be measured and represented by variables based on quantitative empirical data. By defining the degree of flexibility as the freedom the students have to choose when and where to conduct their studies the phenomena is to a large extend objectively determined. The four-structured NBLE provides a high degree of flexibility. In fact the students are forced to work independent of real-time contact with teachers and instructors.

2.1.5.3 Resource requirements

The phenomena «Resource requirements» refers to the amount of resources required both by the students and the educational institution, for delivering a course using NBLEs. Based on this definition the phenomena «Resource requirements» is almost entirely, objectively described and measurable by variables based on quantitative empirical data.

With learning process at colleges and universities the following groups of variables are considered as the main determinants of the resource requirements:

- Workload of tutors/supervisors/mentors/teachers
- Workload of students
- Work load of the technical support staff at the «Help desk» of the educational institution
- Cost of technology required to deliver the net based learning process
- Cost of the technology required by the students to follow the net based learning process.

When concluding on the resource requirements, determined by measuring the above groups of variables, the «values» relative to what would be the situation with traditional lecture based learning processes is of major importance. Most learning processes require some resources for all these groups. In addition to the above factors there will also be more hidden and not easily measurable factors, requiring resources. Especially when introducing learning processes, applying high tech solutions, the hidden factors may be extensively present in the form of frustrations and inter colleagues learning. Time spent by employees, teaching or explaining other colleagues how to use modern technology, is believed to be a highly underestimated cost. However, by the very nature of these factors, they are difficult to detect and measure.

2.1.5.4 Learner's satisfaction

The phenomena «Learner's satisfaction» refers to how satisfied or «happy» the students are with the learning process and is strictly not a success factor since it is not a major goal to please the students. Determining the degree of Learners' satisfaction is almost entirely based on students' attitude. The challenge is to distinguish between different causes for students' satisfaction or dissatisfaction. Since the main objective of measuring learners' satisfaction, is to conclude on how this may effect the learning progression, care must be taken to conduct observations both during and after the learning process is terminated. Experience from the experimentation in PedTek clearly indicates that the students' opinions about the learning process changes considerably during the term. With untraditional pedagogy such as PBL and CL, the level of frustration is often high at the early stages of the learning process. But, when the learning process is terminated, and the majority of the students realize that they have achieved good marks and experienced a high learning outcome, the attitude is considerably changed. At this stage, even the most critical students shifts attitude and become positive spokesmen for the new type of learning process, but this is of little help during the learning process. It is however, also important to include the students final attitude, since this will be the basis of what they communicate to other potential students in the «students' marked».

2.2 The Case

Since the start in 1997, the R&D process of PedTek has organized experiments, mainly involving two undergraduate courses at Hedmark University College (HUC). The two courses, Project Management (IN40) and Systems Development (IS12), are mandatory for undergraduate students in Computer Science. Experimenting with real courses and real students at the Computer Science dept. has been a considerably advantage, by enabling the members of the PedTek project to integrate and closely combine R&D activity and the role as «lecturers» or mentors for students. The R&D objects, the students, have by this been easily available, and hence made it possible to avoid a considerably shift of focus when switching between teaching and research, which is a common problem related to organizing the work of faculty members at universities and colleges. The Project management course represented the main test case throughout the PedTek experimentation. The System management course was not introduced as a test case until the fall of 2001. In addition to these two courses, empirical data is also, to a lesser extent, retrieved from a course program organized by a project financed by the European Union, involving the University of Karlstad in Sweden and Lillehammer University College.

2.2.1 The Project Management course, IN40 at HUC

The project management course, IN40, has been a mandatory course for undergraduate Computer Science students at HUC since 1990. From 1990 to 1997 the course was organized with traditional, lecture-based learning processes. At the start of PedTek in 1997 the course was reorganized according to a preliminary requirement specification for the first prototype tested during the fall of 1997. The project management course has been attended by approximately 50 second year students each fall term. IN40 has a workload of 2 credits and the objective is to provide the students with basic knowledge and skills required for managing and participating in projects, with emphasize on systems development projects. The curriculum is based on the textbook, Goal Directed Project management by Andersen, Grude and Haug (NKI publishing company), and an article on Leadership from the Phd thesis of Leikny Øgrim.

2.2.2 The System Development course, IS12 at HUC

The Systems Development course, IS12, has been mandatory for Computer Science students at HUC since 1989. Until the fall of 2001, IS12 was organized with traditional lecture-based learning process. In 2002, during the later stages of the PedTek project, the course was reorganized as a net based learning environment, based on the, at that time experience of the experimentation with the Project management course. The curriculum is based on the textbook, Systemutvikling (Systems Development) by Andersen (NKI publishing company and Handbook in Systems Development by Berg M. C.

2.2.3 The NBLE prototypes

The first NBLE prototype was designed and tested in PedTek during the fall term of 1997. When embarking on the project we had limited experience, but strong views on how a Net Based Learning Environment should be designed, organized and implemented in practical educational programs. The views where mainly based on what we had observed and experienced gained by investigating other net based learning systems, organized by other educational institutions, and based on this insight we were not impressed. Most attempts to provide net based learning at that time, failed to combine technology and pedagogy satisfactorily. The technology was used as little more than electronic archives, supporting traditional lecture based learning or organized as courses for self study processes. With the objective of PedTek to experiment with and develop more optimal combinations of pedagogy and technology, the initial challenge was to design a satisfactorily prototype to be tested with «real students».

2.2.4 Theoretical framework and NBLE structure

At the initial stages of PedTek our conception of what would constitute a high quality NBLE was insufficient for formulating a precise requirement specification. With this point of departure an experimental development process appeared as the most viable alternative. Design of the first NBLE prototype was based on experience from distance education projects prior to PedTek. In the design of the first prototypes, great care was taken to include functionality in accordance with Constructivist learning theory. The result of this initial design was realization of a NBLE prototype framework with the following four-component structure:

1. Pre-produced learning material (books, articles, video/film)
2. Learning Management System (LMS).
3. Supervision and exercises.
4. Face to face meetings and workshops.

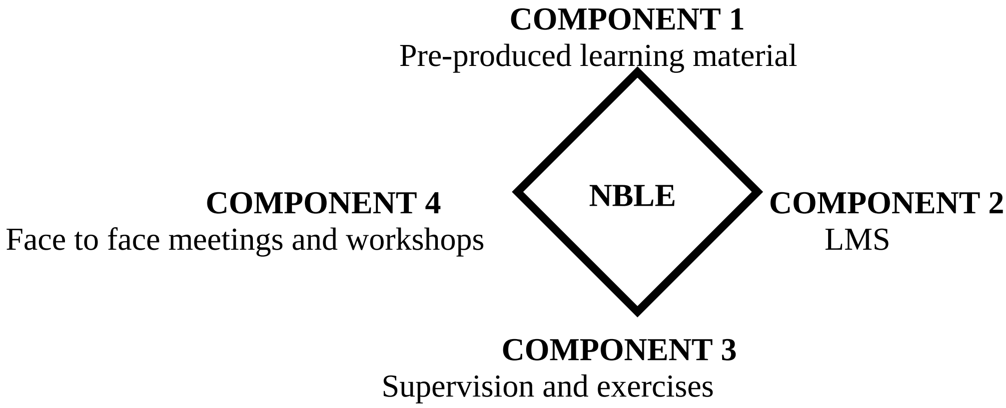


Fig. 2.3
The 4-component NBLE

The NBLE model does not represent a radically new concept, but serves as a guide to systemize and visualize the main functions or building blocks of a net based learning environment. The same components can be identified in most net-based educational programs and are not unique for the PedTek experimentation. In particular during the development process, the model served as a useful and efficient reference for evaluation of the prototypes and discussions among the developers on how improved prototypes should be designed. With this model the development process was relatively free to vary the contents of the components and simultaneously work with a familiar and well defined structure throughout the experimentation. The model was thus convenient for the R&D process by ensuring that we had comparable prototypes. But retrospectively we have found that the 4 component structured model can advantageously also be applied in post development circumstances and in addition the model also serves as a convenient reference for the presentation of results in this report.
In accordance with Constructivist learning theory all the NBLE prototypes were designed with guidelines determined by CL (Collaborative Learning) and PBL

(Problem Based Learning). This represented a learning environment, very different from the traditional push-based way of organizing learning processes. The objective was to provide the students with favorable conditions for getting relevant experiences and conditions for «pulling» required information from a surrounding support system, thus allowing for the construction of new knowledge. It must however be emphasized that the original goal was to test learning situations designed according to CSdCL principles, but this was only partly achieved. All students attending the experimental courses, worked in groups, but only the collaborative interaction with the experts, the supervisors and mentors involved physical distance and applied computer supported communication. The collaborative activity among students in the same groups was almost entirely based on face-to-face communication. The experimental situations can thus be characterized as being a «semi» CSdCL case.

From the experience we had by insight in other net-based learning systems, it was apparent that the prototypes had to be organized as «hybrid» solutions. This implies a combination of traditional lectures, physical meetings, PBL and CL based pedagogy and the use of traditional course material with artifacts such as textbooks and articles. The experimental development process could then focus on what should be included in each component based on specific knowledge of the conditions in which the learning process was taking place.

2.2.4.1 Component 1: Pre-produced learning material

The purpose of isolating pre-produced learning material in one component of the NBLE is to allow the developers to focus on what kind of material can and should be prepared prior to the start of the learning process. Most organized learning processes, as part of a formal educational program, organized and delivered by approved educational institutions, are based on some kind of predefined curriculum. To a varying degree, this requires reference to artifacts such as textbooks, articles or at least suggestions of what to read and where to search for suitable learning material. This represents, in some form or another, what can be characterized as learning material, required for the students to engage in a particular learning process. With the recent years' technological developments, we have experienced that learning material can and should be extended beyond what is represented by paper based, written material. Both multi media technology and artifacts based on experience from the film industry and can and should be included as part of a pre-produced learning material. The use of film in education has long traditions, but is controversial among educators. In the Scandinavian countries, films produced specifically for supporting educational programs has been tried out, with varying degree of success during the last fifty years. The critique, against film as a «pedagogical tool» and the related debate has been closely connected to the more general discussion of technological development and innovations and the effects on society. The effects and benefits of film in education is still to be investigated properly before conclusive statements can be made. However from the experience during the last decade it is reason to be optimistic towards the potential of film as a pedagogical tool.

> «Film adds a new dimension to enlightment and education, just as printing did in the fifteenth century.» (Diesen J. A. 1995)

It is however obvious that even if film is considered to have a large potential as a pedagogical tool, success require careful consideration of how and where to apply the tool.

> «Film is no open sesame to education. Used wisely, it is an invaluable aid – that is all.» Diesen J. A. 1995)

And

> «Whether or not a medium's capabilities make a difference in learning depends on how they correspond to the particular learning situation – the task and learners involved – and the way the medium's capabilities are used by the instructional design.» (Kozma 1991 in Diesen 1995)

Producing film or video-based learning material requires relatively large resources and will in most cases be too expensive for «one time» learning processes. Considerable reuse of this material will be required for most practical cases.

The detailness of the learning material will to a large degree, depend on the pedagogical principles of the learning process. Learning process, based on «pure» PBL or CL, must leave the learners with considerably freedom to define their own learning goals and curriculum, and thus, by principles not suggest any or very little specific learning material at the initial stages of the learning process. Defining learning goals and suitable curriculums, under the guidance of a mentor, is included as a part of the learning process and thus, excludes the predefinition and pre production of learning material. With learning process, based on different pedagogical principles, for example Behaviorist learning theory, a well structured and detailed defined collection of predefined learning material will normally be required. In most practical cases, however, learning processes are organized with a pedagogy somewhere between the extreme pedagogical principles, and requires some pre-produced learning material, and hence justifies the inclusion of the component Pre-produced learning material as part of the learning environment.

The objective of Component 1 of the NBLE is to provide the students with optimal opportunities to work independently of the teacher or supervisor. The obvious content of Component 1 is everything, which is included as part of the formal curriculum such as text books, articles and notes. This represents the formal learning material and specifications will be related to the pedagogical principles applied, represented by the contents and functionality of components 3 (Supervision and Exercises). The more information contained in component 1, the more sustainable the students learning process will be and the higher is the degree of flexibility, by allowing the students to be less dependent on dialogue with the supervisor or mentor. This must, however not be interpreted as an attempt to load heavier burdens on the learners, but to provide an efficient supplement to supervision and thus ensuring more optimal learning conditions.

2.2.4.2 Component 2: Learning Management System (LMS)

With net based learning environments, the net-based support system or Learning Management System (LMS) can be considered as the core component. The component is pr. definition required if we want to use the characteristic, NBLE. However, a net-based support system is a required, but far from sufficient component of an efficient NBLE. In many practical applications, defined as net based learning systems, the Learning Management System is in fact the only component. Traditional educational programs are converted to net based learning processes by introducing a standard system, promoted as a net based learning environment without reorganizing other parts of the course. With reference to the PedTek based NBLE model the other three components are required and are equally significant elements of the NBLE.

With a LMS, both intranet, Internet and other net applications can be included. In most practical cases encountered now, and in the near future, the www is likely to be the main basis for comprehensive and commonly available electronically based communication. Flexible educational programs have long traditions in the form of correspondence schools, using traditional postal based mail. The experience from these, relatively successful learning solutions provide us with useful information when establishing educational programs based on electronic communication. With the www, a new generation of flexible or distance education has evolved. In one respect, it can be argued that the www only represent a quantitative step from the old fashion mail, used by correspondence schools for the past half a century. The functionality of web-based support systems is more or less the same as with traditional mail, it only does the same things faster. However, this difference in processing speed is significant with respect to what can be achieved, and thus the www can, in this perspective be defined as a media, qualitatively different from traditional mail systems.

The most obvious and commonly utilized property of the www is the possibility of establishing electronic archives, accessible from geographically distributed locations. Pre-produced learning material and course information is instantly available to all students, regardless of geographical location. This possibility represents by itself, a functionality, which is interesting for traditional lecture, based learning processes and has a considerable potential for supporting flexible learning processes. Applied as a support system for traditional lecture based learning processes, the www, used as an electronic archive, only marginally utilizes the potential of the new technology. But this does not have negative consequences, rather the opposite. The old traditional lecture based learning may be improved. But, if the potential of the new technology is to be fully utilized, the organizing of the learning processes must be changed. The lecture-based pedagogy must be substituted by learning based on other pedagogical principles. When designing learning process for off-campus students, geographically distributed, the change of pedagogy is particularly important. With many contemporary net-based educational programs, the electronic archive function is frequently used as a substitute for teaching and mediating knowledge, which can be characterized as a kind of worst-case scenario. The organizers of distance education programs are then providing the students with a convenient electronic archive, none or very few lectures, and little alternative support from a supervisor or mentor.

If the www is to be used as an electronic archive, this is perfectly acceptable, but it should then be made clear that this is the planned and intended functionality, and a description of how the learning is suppose to take place should be presented to the students. The most important consideration is that the Learning Management System should be designed with a structure and functionality, which supports the pedagogical approach of the learning process. If PBL and CL are applied, the functionality of the web-based support system should support the corresponding pedagogy. The same applies if the pedagogical approach is based on or oriented towards behaviorist learning theory.

With traditional postal based mail systems, the communication between the learners and the supervisors were entirely based on asynchronous communication. The main difference between these conditions and the conditions made possible with electronic communication is the introduction of synchronous communication. And this difference is sufficiently significant to qualify a net-based learning environment as qualitatively different from the traditional postal mail based systems.

2.2.4.3 Component 3: Supervision and exercises

The purpose of introducing a component for supervision and exercises is to draw attention to one of the most important considerations involved when applying Web-based instructional technology. When designing net based educational systems, it is required that the developers and designers are conscious and focused on the theoretical basis of the learning process, and not, as frequently observed, taking for granted that learning takes place when the students are attending the course. The choice of pedagogical approach has implications for the structure and content of the other three components of the NBLE, and to some extend, visa versa. Applying pedagogical principles based on Constructivist learning theory, such as PBL and CL requires different learning material and different functionality of the LMS than is the case with different pedagogical approaches. It also determines the agenda during the face-to-face meetings and workshops. Supervision and exercises represent the main activity of the supervisors and mentors and a substitute for the activity, which traditionally took place in the traditional classrooms and lecture theatres. Achieving efficient supervision and tutorial session, supporting CL and PBL processes is in itself a complex task, and not lesser so when applying electronic communication for mediation. For the support or scaffolding of tutorials, especially with less motivated and inexperienced students, the structure of the interaction is of considerable importance.

> «Three of the factors that have been identified as affecting tutorial outcomes are: (1) Structure of the tutorial interaction (including specific tutor behaviors); (2) degree of student control or regulation of the process; and (3) status within the tutor-tutee relationship.» King A.1997)

2.2.4.4 Component 4: Face to face meetings and workshops

Face to face meetings was not included as part of the learning environment at the initial stages of the PedTek experimentation. The developers were determined to try out solutions with a high degree of flexibility, and gathering the students in face to face meetings represents a reduction of flexibility. With face-to-face meetings the students have to be on a particular location at a particular time. However, as also pointed out earlier the first «face to face free» prototype was not very successful. The effect of meeting the students face to face at the start of the learning process or the beginning of a term turned out to be of vital importance for the learning process ahead. The most obvious reason for arranging real, face to face meetings with the students, was that they were all unfamiliar with the new learning process and needed a more gradual conversion to this untraditional learning process. In many respects, the arrangement of physical meetings is a matter of psychological effects. However, the need for face-to-face meetings is expected to change and be reduced, as the learners are getting increasingly familiar with the new learning process. The next generation of students and NBLEs is therefore likely to require less face-to-face contact.

2.2.4.5 Prototypes tested from 1997 to 2002

From 1997 to 2002 six different prototype versions of a NBLE based on the four-component framework was designed, tested, evaluated and redesigned.

Components / **Prototype version**	**Component 1** Pre-produced learning material	**Component 2** Web-Based support system	**Component 3** PBL based teaching, instructions and exercises	**Component 4** Face to face meetings and workshops
Prototype 1 (1997)	Text material	Dynamics	Simulated virtual enterprise (Web)	Video conferencing
Prototype 2 (1998)	Text material	WebCt	Text based case	Two days face to face
Prototype 3 (1999)	Text material	WebCt	Text based case	Two days face to face
Prototype 4 (2000)	Text and video material	ClassFronter	Text and video based case	Two days face to face
Prototype 5 (2001)	Text and video material	ClassFronter	Text and video based case Marks on problem solving during the process	Three days face to face
Prototype 6 (2002)	Text and video material	ClassFronter	Text and video based case Marks on problem solving during the process	Three days face to face

Fig 2.4
Prototypes and content of each component

Based on test and evaluation of each prototype the components of the next prototype were improved in accordance with the test results. The solution used for Prototype 1 was by far the most ambitious and complex. A virtual enterprise was designed allowing the students to engage in a virtual project with the purpose of introducing a computer based information system in the virtual company. The supervisors took on the roles as employees and managers in the virtual enterprise and the students were allowed and enquraged to retrieve information by asking questions, using e-mail. Videoconferencing was tried out as a substitute for a real face-to-face meeting. The experience from experiments with this first prototype indicated that videoconferencing at that point in time did not allow satisfactorily contact between the teacher and students. Using a virtual enterprise was successful with respect to the learning process but far too demanding and resource consuming for the teacher and instructors. Apart from the video clips introduced in the fourth prototype each component progressed towards containing more simplified material during the development process. The exception was the effort from teachers and instructors related to component 3. The experience with the early prototypes clearly indicated that the instructors needed to be more active in a Constructivist learning process. Feedback from the students indicated that the instructors also should play a more active role in the collaborative process in each group

2. 3 Evaluation of the prototypes

Since the start of the experimental development process in 1997, approximately 650 students have attended the test courses and followed the learning process using different prototypes with NBLE solutions. Results from the evaluation of the NBLE prototypes tested during the experimentation, presented in this chapter, are based on a combination of the different methodologies elaborated and discussed previously in this report (ibid. p. 40). But the main emphasis of the conclusions in this chapter is based on information retrieved by using formal quantitative and qualitative methodology. Conclusions and comments, based on additional insight, gained by using less formalized methodology, combined with the results from the formal methods, are presented in chapter 3 and 4. The presentations in chapter 3 and 4 thus represent more comprehensive discussions and interpretations.

The part the formal methods, represented by questionnaire based surveys, includes response from 153 undergraduate and 13 post graduate students during 2001 and 2002. The response of the survey among undergraduate students is approximately 77% of the total population of students attending the experimental courses. The total number of students attending these courses were

approximately 198 and 153 completed and handed in the questionnaire. The total number of postgraduate students contacted was 34 and 14 returned the questionnaire which represents a response of approximately 41%.
Results from the questionnaire surveys conducted prior to this, from 1997 to 2000 are excluded because these would not contribute to a correct «picture» of the present and so far, final results from the development process. Presenting statistical results, based on these earlier test results would lead to the wrong conclusions, since the tests were based on NBLE solutions, inferior to the latest versions. However, the response from students, based on questionnaire surveys during the period, 1997 to 2000, has been vital as feedback to the experimental development process, for continuously improvements and redesign of the prototypes.

The questionnaire survey conducted with post graduate students provides to some extend, less significant results, for the same reason as with the response from students attending the earlier versions of the experimental learning processes. The data from the postgraduate students is based on their experience when attending the earlier and inferior NBLE solutions. This is a problem since students attending the latest courses will not be in a position to provide feedback, based on work life experience, until a few years from now. But never the less, the feedback is included, and when *they rate the NBLE solutions as satisfactorily or better than the traditional lecture based courses*, it is reason to conclude that the present solutions are at least, equal but probably better than previously tested solutions.

Conclusions drawn and comments made below in the present chapter are mainly with respect to the success criteria, represented by the four phenomena, Learning outcome, Flexibility, Resource requirements and Learner's satisfaction. However, to some extent, comments are also made with respect to the less development focused and more research oriented objectives of the PedTek project. The main bulk of comments and presentation of research results are included in the presentations in chapter 3, 4 and as part of the overall conclusions and recommendations presented in chapter 5.

When presenting the evaluation results, it can easily give the impression that conducting the experiments and performing tests represents cool and emotion free activities, with the developers and researchers observing with their note pads and analyzing tools available. In some cases this has been the case, but in most cases, when attempting radically new solutions, involving real students and many other participants, the level of frustrations and production of endorphins among the developers has been high. To provide a brief glimpse of these situations, a more informal report from the «experimental site» at the start of the projects, is included in the appendices of this report (An Odyssey into the field of distance education and flexible learning).

2.3.1 Limitations of the PedTek framework

The experiments conducted in PedTek and thus all the conclusions are based on results from testing NBLE prototypes with two undergraduate courses in Computer Science at HUC. The limitations of the PedTek framework with respect to generalizations, is therefore determined by to the extent these courses and conditions are representative for a larger population. The tests were also limited to applying PBL and CL as pedagogical principles, and thus excludes experience with solutions based on different pedagogical principles.

2.3.2 Prototype performance

Prototype performance refers to the overall quality of the latest, and so far best prototypes tested during the experimental development process. The presentation of test results below in this chapter, is restricted to «pure» analysis, and does not include extensive interpretations and conclusions. This is left to the discussion and comments in the two next chapters. The purpose of presenting «pure» analysis result is mainly to provide a background for later discussions, conclusions and recommendations. But having declared this, it should also be kept in mind that the borderline between results from analysis and interpretations is not clear and sharp. It is difficult to make emotion-free and objective comments without disclosing preferences and value related statements. Traditionally the term performance refers to description of technology products such as cars, aircrafts etc. But despite this tradition, and hence running the risk of being accused of relating the R&D process too much to the tradition in the natural sciences, the term is used.

The presentations and comments below in this chapter is mainly done with respect to the four success criteria, and based on the response from the surveys and observations. As an overall comment it can be stated that the latest NBLE solutions proved to be promising with respect to utilizing the potential of IC technology. It was also apparent that a shift of pedagogical approach from PUSH to PULL enhanced the quality of the learning process for all categories of students, including the traditional on-campus students.

2.3.2.1 Learning outcome

The most frequently asked question, by the developers, during the early stages of the experimental development process was: Do the students learn what they are supposed to learn with the new, untraditional learning process? And the issue of satisfactorily learning outcome has been a major concern of the developers and high on the agenda throughout the development process.

When embarking on the experimental development process in 1997, the students attending the Project management course were involved in a radically different learning process, compared to what they were used to and prepared for. All other courses and educational programs at HUC at that time, were organized with traditional lecturing in lecture theatres. Only a few students were very familiar with the use of the Internet and e-mail based communication was recently introduced «for real» communication. A few courses at HUC at that time had started to present course information and in some cases also part of the learning material on web sites. Since then, the conditions have changed dramatically with respect to the students’ insight in the new learning process and with respect to the use of high tech course support systems. One of the most significant effects of this early situation in the experimental process was a high level of frustration among the students and at times they expressed an almost hostile attitude toward the new type of learning process. With a PBL and CL oriented pedagogy the students experienced a strong feeling of being left on their own, mainly because they could not figure out where and when the learning was supposed to take place. With the absence of gatherings in a lecture theatre, with a teacher sharing his knowledge orally, the traditional learning ritual situations and sites had disappeared. And it must be admitted that as developers we were to a large part to blame for this situation, by not ensuring that sufficient and satisfactorily information reached the students. But it must be emphasized that we did try, and at times we were even worried that we over-informed the students. In this situation, when testing the first prototypes of an NBLE with «real» students, the level of concern and even frustrations among the developers were high. The main concern was related to the question of whether the students, attending the experimental course, were suffering from unsuccessful organizing and unsuitable pedagogical solutions. And our concern was real since we at that time had very little experience with managing similar learning processes.

The main reason for introducing this description of the development situation is to explain and expose some of the driving forces behind our eager to observe the results of the experimental solutions. In particular because the task of determining the learning outcome of a learning process is a complex exercise, even based on the somewhat simplified definition of the phenomena applied. A variety of situations were used for trying to detect if the new learning processes at least were satisfactorily compared to traditional lecture based learning. We observed and focused on how the students performed in situations, requiring knowledge and skills in issues related to project management and participation in project groups, outside the formal course context. This included asking test questions in order to reveal the students' knowledge and insight in both the course curriculum and the terminology of project management issues. By the time the first students terminated the course, and obtained their marks on the basis of exams and problems solved during the course, we could conclude, with a reasonable degree of certainty, that the learning outcome was not less than with traditional lecture based learning process. And as the students, having attended the course, where involved in their final year project, we were utterly convinced that we at least not were on a completely wrong track. As the experimental development progressed, from 1997 and onwards, with continuously redesign and testing of NBLE prototypes, with both setbacks and considerably leaps forward, we gradually grew more confident. But throughout the six years of experimentation, the intensity of observing the phenomena, Learning outcome, never decreased significantly. And by the termination of the PedTek project and testing the so far last formally experimental solution, our confidence with respect to the learning outcome of the NBLE solutions was high.

As explained earlier, determining the learning outcome of a particular learning process represents a complex methodological exercise. Paradoxically, universities and colleges use marks as the main indicator of the students proficiency in a particular subject, and frequently the marks are the only reference the students have when applying for jobs or pursuing a further academic carrier. Simultaneously, the research community and educators are reluctant to accept marks as a sufficient indicator, claiming that several other aspects must be considered to determine the qualifications of a particular candidate. However, not attempting to completely sort out this issue, it is reasonable to assume that the marks, at least to some extend are reflecting the knowledge level and skills of the candidates.

With the Project management course previously conducted in a traditional lecture based form, using the same curriculum, the marks obtained by the «new» students could be compared with the achievements of the «old» students. Available statistics indicates that the introduction of the NBLE solution had a positive effect on the average marks of the students attending the course.

Average grade Traditional course	2.7
Average grade NBLE course	2.1

Best grade is 1.0. Lowest grade for passing exam is 4.0

Table 2.5
Comparison of marks between traditional courses and courses using NBLE

The test of each prototype was followed by a questionnaire survey conducted among the undergraduate students.

The survey conducted after testing the sixth prototype indicate that 76% of the students believed that attending the course made them more competent to manage projects in the future. 68% of the students expressed that they considered the learning effects of the NBLE based course to be better or the same as for a traditional lecture based course and 32% answered that they had learned less. A survey conducted in 2003 among postgraduate students, having been employed in jobs as programmers and systems developers for periods from one to three years, indicates that 73% considered the learning outcome of the Project Management course to be useful or very useful for the tasks they *encountered in their present jobs. And 91% of the same post graduate students considered the overall quality of the project Management course to be good or very good.*

Interviews with groups of students also indicate that the majority believed that they were learning more by attending the NBLE process than a traditional lecture based course. This result is confirmed by observations of the same students' competence in planning and organizing their final year project during the spring terms. Students who had actively participated in the NBLE learning process seemed to better equipped for managing and participating in real projects than students with background in a traditional lecture based course in project management.

In view of the uncertainties involved in measuring and determining the learning outcome of learning processes, interpretations of the test results must be conducted with some care. It is, however, reasonably safe to conclude that the learning outcome of the most recent NBLE prototypes tested, is at least as high, and probably higher than with traditional, lecture based learning processes. The results from the questionnaire surveys among postgraduate students with working life experience, indicates that these candidates are even more positive to the learning outcome than the undergraduate students. A result, which clearly support the conclusion that the learning outcome of the NBLE prototypes is at least satisfactorily.

2.3.2.2 Flexibility

Ensuring flexibility of the NBLE based learning processes combined with solutions, providing the students with at least a satisfactorily learning outcome was a major concern for the development work. With the predefined development goals of providing off-campus students with educational programs, a certain degree of flexibility was absolutely necessary for a reasonably successful development process. Failing to provide satisfactorily flexibility could have left us with efficient learning processes, but useless solutions for learners in job and with family obligations. During the development process, only a few of the students attending the experimental courses were in fact «real» off-campus students. The majority were ordinary students, spending most of the weekdays on campus. This represents a limitation of the test conditions, because the test results did not include significant feedback from students requiring flexibility. The conclusions on flexibility are to a large extent limited to what we, as developers and researchers considered, and the on-campus students' opinions on what they believed would constitute flexibility if they were off-campus students. However, the on-campus students are also, to some extent in a situation where flexibility is an advantage.

The main background for conclusions on the flexibility of the NBLE based learning processes is estimating and considering how much the students were required to be present at a certain location at certain times during the term, compared with what would be the case with traditional lecture based learning.

With the two latest NBLE prototypes tested, in 2001 and 2002, the students were recommended to attend three face-to-face meetings during a term. Each meeting lasted for approximately five hours. Attending the meetings where not mandatory but strongly recommended. However, attending the first meeting was most critical and recommended for all students, not being familiar with the pedagogy or in need of some supervision for using the LMS. Choosing to organize as many as three face-to-face meetings during the term had to do with the fact that most of the students where on-campus students and meetings were not of great inconvenience to most of these. And in addition, we did not want to provoke the on-campus students, by excluding face-to-face meetings, with the risk of being characterized as not being sufficiently active as instructors. With «real» off-campus students, and in particular if these where accustomed to Problem based learning and Collaborative learning, it would have been satisfactorily with only one initial face to face meeting, and the more the students get used to this new form of learning the fewer hours of face to face gatherings will be required.

Requirements on arranging meetings between students and supervisors at a particular location at a particular time will, with future NBLE based learning process be restricted to approximately 5 hours, during one day at the start of a term. In addition, depending on the type of final exam applied, the students may be required to meet for individual or group based exam, for a few hours at the end of the term. Handing in reports from mandatory or at least strongly recommended solutions to exercises is required at predefined deadlines three times during the term, but this do not require physical presence at a certain location. The reports are sent as attachment to e-mail or using the LMS.

With the latest NBLE prototypes, the students were only required to attend a lecture theatre for five hours on one single day during the term and comply with the deadlines for handing in reports from exercises three times a term. The rest of the term, the students were free to choose when and where to conduct their studies. With a comparable course, applying traditional lecture based learning, the students are required, or strongly recommended to attend approximately three to four hours of on-campus lecturing each week.

With pedagogy, requiring the students to work in groups and organize the group work based on principles from CL, the individual freedom to choose time and place to study was to some extent limiting the flexibility. Even if the students were free to organize this work, engaging in collaborative activities implies reduced flexibility. For some student groups, much of the communication and collaborative dialogue was organized electronically, but all groups reported that they where gathered in physical meetings each week. *Approximately 80% of the students reported that they spend five hours or less, in physical meetings with the group pr week and 18% spend between six and ten hours.* By defining the degree of flexibility as the freedom the students have to choose when and where to conduct their studies, the phenomena is to a large extend objectively determined. The four-structured NBLE provides a high degree of flexibility. In fact the students are forced to work independently of real-time contact with teachers and instructors. In interviews with students this was clearly confirmed. However, the experiments were conducted with the majority of the learners being on-campus students, not having the same need for flexibility as off-campus students. It is therefore reason to believe that most of them only have a theoretical relation to the advantages of flexibility.

2.3.2.3 Resource requirements

Accurate estimation of all resources required for organizing and conducting a formal learning process in an educational institution is difficult. Many of the activities involved are integrated in other, ordinary activities and therefore difficult to isolate and measure. With a 2 credit course, organized as a traditional lecture based learning process a lecturer is, as a rule of thumb, allowed approximately twelve hours pr week in average for «doing the job». This includes lecturing and planning, preparing course material, supervision of students, preparing and marking the exams. No statistics is available for estimating the resources required by the administrative and technical staff related to specific courses or educational programs.

Testing of the first three prototypes in 1997, 1998 and 1999, indicated that the solutions required resources from the institution in the order of two to three times the resources required for conducting a traditional lecturing based course. The majority of these resources are represented by the efforts of teachers and instructors in preparing and conducting the initial workshop and supervising the students. This was clearly unacceptable and in the redesign of the fourth prototype great care was taken to find more economical solutions. The results from the testing of the fourth prototype indicated that the cost pr student then was comparable with the cost involved with a traditional lecture based course. But as opposed to lecture based courses the costs involved when applying PBL and CL are strongly dependent on the number of students. Calculations indicate that with less than one hundred students attending a NBLE based course the resources required is less than for comparable lecture based programs.

From the questionnaire survey there are indications that the students find the NBLE course more demanding than following a lecture based course. 70% of the students claimed they spent the same or more hours pr week studying Project Management as NBLE students than they spent on other comparable 2 credit courses. However when asked how many hours they spent pr week, 70% answered that they spend less than 5 hours a week. Considering that a 2 credit course amounts to approximately 20% of the total work load it can be concluded that 70% of the students spend 25 hours or less pr week studying, which indicates that the work load related to the NBLE solution is not excessive, related to what should be expected by the students.

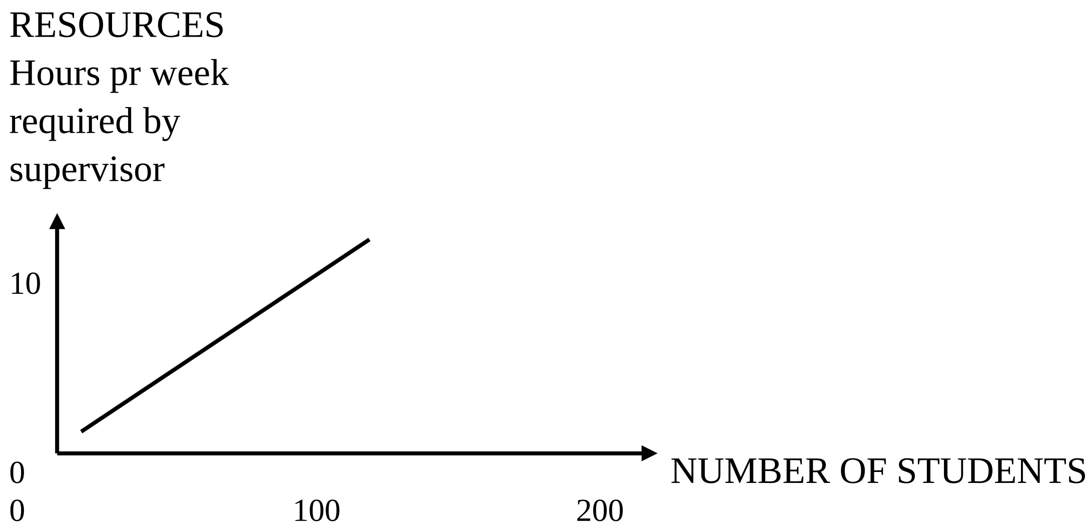


Fig 2.6
Resources required by supervisor and number of students following the course

2.3.2.4 Learner's satisfaction

Of the four phenomena, used as success criteria, determining the Learner's satisfaction is by definition, entirely based on the students' attitudes. The main objective of including this phenomenon is as previously explained, related to the effect it may have on the students' motivation for learning during the course. The main source of information regarding the Learner's satisfaction phenomena is what we have observed through general contact with the students while they have been attending the course and to some extend the response to questions in the questionnaire.

From the testing of the first prototypes and throughout the six years of development the change in students attitude towards the untraditional PBL and CL based learning process has been considerable. The frustrations and even hostile attitude from the students attending the first experimental courses gradually decreased and students attending the latest two versions hardly expressed any discontent with the learning process. Based on this, it is reasonable to conclude that with the present solutions, problems related to the new and untraditional learning process, based on PBL and CL, is no longer an issue of concern among the students. The explanation of this is, partly that we are now organizing the courses and the learning process in more optimal ways and the students are provided with sufficient information at the start of the learning process. The fact that the present students also are convinced, by charring the experience of previous students, that the learning outcome is high, probably also contributes to a change in attitude.

It must however be taken seriously when approximately 47% of the students, expresses in the questionnaires that they don't recommend that the majority of the courses at HUC should be organized in the same way as the NBLE based courses used for experimentation. The explanation of this relatively negative attitude is not immediately apparent since approximately 40% of the same students consider the overall quality of the course to be high or very high. And approximately 45% of the students answer that they would have attended the course even if it not were mandatory.

3. Structure and functionality of Net Based Learning Environments (NBLE)

When addressing issues related to the structure and functionality of NBLEs this only includes part of the considerations involved in the process of realizing and implementing efficient, flexible education. Other important issues related to the process of organizing and delivering flexible education requires different attention and these are discussed separately in the next chapter (Chapter 4. Organizing and delivering Net Based Learning Systems). The objective of the present chapter is to discuss and elaborate on pedagogical and technological considerations involved in the process of designing NBLEs for particular students, situations and curriculums.

The preliminary NBLE with a 4-component structure (ibid. p.50) based on pedagogical principles from Collaborative Learning (CL) and Problem Based Learning (PBL), has throughout the development process continually been redesigned, tested and revised. Based on the four main criteria of success, Learning Outcome, Flexibility, Resource Requirements and Learner's Satisfaction, the 4-component structure and the pedagogical principles based on CL and PBL have, to a large degree, passed the experimental tests. The structure of the original design has proven to represent a viable solution, but not unconditionally. When conducting the tests, great care has been taken to maintain a critical attitude towards the practical usability of the original design. This has, among several other conclusions, indicated a necessity for considerably changes in the content of each of the four components throughout the development process. And even if the present and latest version of the NBLE can be characterized as a high quality solution with respect to certain success criteria, changes in the contents of each component will continuously be required in the future. In particular, the rate of technological development, making new solutions practically applicable, will contribute to determine, at any time, what is the best design and content of each component. And further, for the same reason it may also be necessary and desirable to deviate from the original 4-component structured NBLE. With respect to the pedagogical foundation of the NBLE, it can be concluded that the original solution is relatively stable, at least with respect to certain groups of users. However, results from the experimentation indicate that it may be required, on certain conditions, to design and implement solutions based on different pedagogical principles. But this represents more speculative and not conclusive statements and is presented as hypothesizes below.

The empirical material available from the experimental process is to some extent insufficient for clearly concluding that the quality of the latest version of NBLE is superior to traditional lecture based learning processes. Strictly, the results only allow us to conclude that the quality of the NBLE is not inferior to a traditional lecture based learning processes. When interpreting the results from the PedTek project it must be emphasized that the experience is limited to experimentation with particular undergraduate courses. And further, that the NBLE prototypes were all designed, based on principles from Constructivist learning theory. Even if it is likely that the results and conclusions from the PedTek experiments can be transferred to other fields of education, using different curriculums, generalization of the results involves some uncertainties.

3.1 Knowledge PUSH and knowledge PULL

Traditional education, with classrooms and lecture theaters as significant learning environments, applies a pedagogy, which can be characterized as a knowledge PUSH approach. A presumably skilled and competent person, the teacher, attempts to push knowledge across to the students in a classroom or lecture theatre. The teacher lectures and the student listen and have the role of passive, rather than active participants as if the knowledge the teacher has can be transmitted directly to the students (ibid. p10). Cultural constraints and efficiency considerations have reinforced and maintained this type of educational systems despite a growing appreciation that it does not provide the students with optimal learning conditions. With advances in the field of educational psychology and pedagogy, during the last century, it gradually became clearer that optimal learning processes, in most cases, requires favorable conditions for active search for new knowledge and reflections. Learners should be active participants, interacting with peers and experts in the learning process and provided with conditions for pulling knowledge from the surrounding environment. During the last few decades, with development and advances in the field of instructional technology, the educational community has gradually realized that applying alternatives to traditional education systems has become practically feasible. This has initiated and contributed to increased efforts to develop and implement educational systems, combining efficiency and alternative pedagogy. The progress in this field is not particularly high, since traditional thinking prevails, accompanied by other development-inhibiting factors. To claim, that a shift in educational paradigm, from knowledge PUSH to learning motivated knowledge PULL is taking place, can to some extend be justified but presently this claim seems to be a little premature. Especially if we apply the strict definition used by Thomas Kuhn in his classical work «The Structure of Scientific Revolutions» from 1962.

> «Ironically, the ultimate lesson of this form of analysis is that the revolutionary changes that Kuhn described as paradigm shifts are always difficult to forsee and, in particular, cannot be adduced from the study of past history.» (Koshmann T. 1996)

The data from questionnaire surveys and observations collected throughout the PedTek experiments clearly indicates that a shift of pedagogical approach from knowledge PUSH to knowledge PULL improves the students learning conditions, but not unconditionally. Under certain conditions with particular students and situations, a knowledge PULL pedagogy did not have positive effects on the learning conditions. This observation is the background for pointing at the need for instructional design based on adaptive solutions and this is further elaborated and discussed below in this chapter. With the limitations given by the experimental framework of PedTek, generalization of the results is clearly restricted, and do not allow conclusions pointing towards a general shift in educational paradigm. But with the progressively improved NBLE prototypes tested, during the course of six years, it can be concluded that solutions based on a PULL based pedagogy, for the test cases, is superior to traditionally, lecture based pedagogy. The students at Hedmark University College, attending the experimental courses in Project Management and Systems Development scored high on learning outcome and there are reasons to conclude, much higher than they would have done with traditional learning processes. The enhancement of knowledge among the students was probably higher than what would have been the case with traditional learning processes.

The question of what is the best or correct pedagogical approach can, however, not be reduced to a question of which pedagogical method contributes to the highest score when it comes to learning outcome. Cost effectiveness and for applications involving distance students flexibility and learners satisfaction, has to be taken into account when evaluating the practical usability of a pedagogical solution. During the course of developing and experimenting with NBLEs the cost effectiveness and the flexibility of the solutions was considerably improved. The first prototypes tested, scored low on the cost effectiveness variables but through continually improvements, the present and so far last prototype is comparable in performance, to the cost effectiveness of traditionally lecture based educational programs. And the same solutions provide the students with a high degree of flexibility and scores high on learners' satisfaction. On this background we are now in a position to conclude, that the development process has provided us with solutions, at least comparable in overall performance with traditional learning processes and far better with respect to learning outcome. However, as pointed out above, this conclusion is not unconditionally supported by the test results.

The experimental development process produced a high performance version of NBLE, for the majority of the students following the test courses, but for some, the NBLE turned out to be less satisfactorily. In particular the less motivated and less mature students found the knowledge PULL based pedagogy unsatisfactorily and unsuitable. With some uncertainty it is reason to conclude that the development process has produced NBLE solutions very satisfactorily for some and equally unsatisfactorily for others. The effect of this is serious in the sense that it could introduce a barrier in the educational system, excluding the less motivated and less mature students, unwilling to take full responsibility for own learning. This also rises the question of a general shift from knowledge PUSH to knowledge PULL is possible and desirable. The key to successful applications of the knowledge PULL based solutions, will be to find ways to ensure that all students take sufficient responsibility for own learning. With the improvements included in the design of the sixth NBLE prototype the evaluation indicates that the solution represents an interesting alternative to traditional push-based education. The shift from knowledge PUSH to learning motivated knowledge PULL has efficiently utilized the potential of modern ICT for supporting learning processes. By combining modern ICT with pedagogy based on Constructivist learning theory, efficient flexible learning environments for off-campus students can be realized. Evaluation of the sixth prototype indicates that the NBLE provides the students with a learning environment, allowing flexibility in accordance with the requirements of off-campus students. Enhancement of knowledge can take place independent of real-time contact with a teacher or instructor. However, with a learning process based on collaboration the interdependence between students in a group imposes limitations on the flexibility. Balancing the advantages of collaboration with the need for flexibility may therefore represent a compromise.

3.1.1 Responsibility for own learning

For most teachers and mediators of knowledge and information the ideal learner or receiver of information is a person motivated and eager to strive for acquiring the knowledge and information provided. But, as most experienced teachers and mentors have realized, the ideal learner is in many cases an illusion. Students embark on educational programs for many different reasons and many seem to be less concerned with acquiring new knowledge about the issues involved and the task of establishing active learning environments is not trivial.

> «Design of online distributed collaborative learning process based on active participation seems a complex challenge.» (Collins, 1997; Bates, 1999; Harasim, 1999 in E. Sørensen 2002)

The students at Hedmark University College (HUC), following the experimental courses in Project Management, represented learners with very different degree of working life experience and motivation for acquiring knowledge related to the curriculum. These differences seem to correlate significantly with attitude towards the organization of the learning process, their studying efforts and their learning outcome. The less experienced students, with a correspondingly less ability to appreciate the importance of acquiring knowledge of issues related to the curriculum, naturally also lacked motivation for studying. These students frequently expressed complaints about the organizing of the courses and in particular about the feeling of being left on their own. Despite invitations from mentors to make use of the supervising facilities through electronic communication and in some cases even by physical meetings, these students maintained their negative attitude towards the course and stayed relatively passive. On the other hand, the more mature students, with experience from work life and with a high degree of motivation, found the learning process interesting and scored high on learning outcome.

By itself, these observations are not very surprising, rather the contrary. They confirm what most teachers and mentors know. Motivated students are happier and learn more. However, the significance of these observations is greater and more relevant for the study of PULL based pedagogy applied in connection with NBLEs. These pedagogical solutions seem to be more vulnerable to students' attitude and motivation than traditional knowledge PUSH based learning.

> «In traditional approaches to education, the responsibility for learning lies with the instructor. Teachers and curriculum designers had defined as their responsibility identifying, to a high degree of precision, just what the student needs to know, specifying the behavior that would certify reaching the objective, and specifying the context in which the behavior should be evaluated.» (Gagne, 1972; Mager, 1962; Merrill, 1982; in Koschmann 1996)

Observations of the Project management students at HUC indicates that if the students did not get «on the right track» relatively early in the learning process they had a tendency to fall further back as the process progressed. A possible explanation is that the pull based learning process do not allow for concentrated and «batch oriented» study efforts in the same way as lecture based learning, where much of the course work can be postponed to a period, just before the exam, at the end of the term. To be successful, a knowledge pull based approach requires that students take more responsibility for own learning throughout the process than with traditional lecture based learning.

We may want ideal situations and ideal students, hungry to learn what we offer, but it's very likely that this will not always be the case. As educators we have to provide satisfactorily learning conditions for a wide range of students and situations. When applying a pull based pedagogical approach, motivation must be considered as a critical factor. A main conclusion is that effort invested in enhancing the learners' motivation will give a satisfactorily pay-off.

3.2 User adapted design

Few will disagree with the statement that it is ideal and desirable for teachers and mediators to have highly motivated and hard working learners. But as pointed out above this is not always the case. Ideal situations are rare and effort should be invested in activities to increase motivation early in any learning process and in particular for knowledge PULL based learning processes. But there are indications that this represents an insurmountable obstacle in many practical situations. It is likely that, within any practical framework, succeeding in building motivation and interest is not viable. We will probably have to accept that some students will never reach a sufficient degree of motivation, but they will never the less put in some effort to cope with requirements of the knowledge pull based learning process. And, unless we reject these students, and leave them on their own, it is obviously a challenge to provide them with satisfactorily learning conditions by applying more tailor-made solutions, adapted to individual students' abilities and situations. Care should be taken to consider how the learning process could be adapted to cater for the <u>not so ideal students.</u>

With this in mind, it became gradually more pertinent, as the experimental work in PedTek progressed, to consider different learning strategies for different students. Through talks and interviews with the test students at HUC it became clear that the general validity of the basic, underlying pedagogical philosophy of the NBLE prototypes had to be questioned. And consequently it had to be asked if any single one and particular learning theory unconditionally represent the correct model of how people learn. If Behaviorism is correct and describes how people learn is then other theories, such as Constructivism, «wrong»? Or is it the case that Behaviorism is valid under certain conditions and Constructivism under other conditions in the sense that they are to some extent complementary? (ibid. p 21).

There are indications that the community of educators would benefit from adapting a more open mind approach to the task of accomplishing practical learning processes and in particular when designing NBLEs. Among pedagogical researchers and practitioners, as in many other fields, the tendency to paradigmatic thinking prevails, and different cultures or «schools» develops, separated by considerably barriers. Very few references can be found, which discusses inter school or inter paradigmatic issues. It's either a matter of justifying, arguing and promoting one particular pedagogical approach or the other as the only «correct conviction».

3.2.1 Critical variables

The test results from the PedTek experiments, as pointed out, impose considerably limitations on the generalizability of the results from the analysis. The empirical data available are only sufficient for making statements and conclusions with validity for situations and conditions resembling the test cases and conditions. The uncertainty involved by this constraint, with respect to generalization, is high. But there is reason to at least conclude that (ibid. P.51) the test case and conditions are not too atypical for undergraduate courses in natural and social sciences. At least, the empirical material is sufficiently representative as a background for hypothesizing about pedagogical solutions under different circumstances. Hypothesis, which should be the objective of further research to test.

Results from the PedTek tests inspires to ask under what circumstances and conditions could it be advantageous to apply a pedagogy based on other learning theories than Constructivism. And further what pedagogical alternatives and solutions are best suited for the different circumstances encountered. With insufficient empirical material from test cases or other observations the reasoning on this issues will have to somewhat speculative.

The most definite conclusions, which can be drawn from the test results, in this context, are that the tendency of a positive correlation between the degree of motivation of the learners and the suitability of Constructivist based pedagogy is relatively clear. The more motivated students are the more likely they are to take responsibility for their own learning and hence the more a reflective and open learning processes can be applied. But it is not obvious what is the best pedagogy and learning process for the less motivated students. The experience gained through the experimentation in the PedTek project indicates that the less mature, less motivated and less experienced students, benefited considerably from very clear and direct encouragements from the supervisor. In fact, by being conscious of this apparent effect of positive feedback from the supervisor, it has been tempting to use this type of stimuli, even in situations where it’s not really deserved.

Further reasoning along this line has led to a conclusion that some factors and variables are likely to be important determinators when deciding what are the most suitable pedagogical solutions. Firstly, based on the reasoning above the most obvious variables to be identified as critical are those describing the learners' motivation. Secondly, variables related to the learning culture of the learners present and previous environment is likely to be of interest. In this context, learning culture describes the environments' attitude towards investing effort to learn and acceptance of deferred gratification. Thirdly, the importance of gaining new knowledge is likely to be critical. Or phrased in a different way, the consequence of failing to gain new knowledge is critical. Fourthly, the length of the learning process is critical. And the fifth factor, variables describing the issue to be learned or the course curriculum is of interest. A more precise and well-structured subject is likely to require a different pedagogical approach than an imprecise and ill-structured subject.

It can be hypothesized that variables describing the following five factors should be considered as critical when considering which learning theory should be the basis for the choice of pedagogical solution:

1. Learners motivation
2. Learning culture
3. Consequence of failure
4. Duration of the learning process
5. Type of curriculum

Different values on these variables invites for applying pedagogical solutions based on the whole specter of learning theories with Behaviorism in one end and Constructivism in the other. In a situation with low motivation, poorly developed learning culture, large consequences of failure, short duration of the learning process and a precise and well-structured subject, pedagogical solutions based on behaviorism is likely to be most successful. And in a situation with high learning motivation, well developed learning culture, small consequences of failure, a long learning process and a less precise and ill-structured subject, pedagogical solutions based on Constructivism is to be preferred.

Preferred learning process / Variable	Constructivist	Behaviorist
Learner's motivation	High	Low
Learning culture	Well developed	Poorly developed
Consequence of failure	Small	Large
Duration of learning process	Long	Short
Type of curriculum	Ill structured	Well-structured

Fig 3.1
Critical variables and preferred learning process

Well aware that the conclusions above are controversial and probably unacceptable for parts of the present educational community, it is important to emphasize that the conclusions are not based on formal research findings. They are to be considered as a combination of creative speculations and experience based reflections. But it is felt that the conclusions are too important to be ignored because they may not pass the strict tests of scientific reasoning. With a lack of sufficient scientifically valid data to justify the conclusion that learning theories have conditional validity, the line of reasoning behind the proposed conclusions is supported by exemplifications. By introducing examples, involving extreme situations, it may become clearer, why it is considered justifiable to assume that pedagogical solutions, based on different learning theories, are required in different situations.

«Behaviorist» example:

> An example of an extreme situation can be that we are faced with the task of getting an unmotivated, kind of lazy, little experienced person with very little formal education to pilot an aircraft in very short time from now (and you are yourself to be one of the passengers). This situation represents conditions with extremes values on the critical variables. The learner’s motivation is low, with little formal education, the learning culture is poor, consequences of failure to learn are large, duration of the learning process is short, the curriculum is precise and the issue is well structured. Based on this brief description of an

imaginary situation, the question of what pedagogical approach is likely to ensure a safest possible flight should be asked. Or rather, it should be considered if it’s satisfactorily, in this situation, to apply a learning process relying on the learner taking responsibility of own learning. Faced with the challenges of this imaginary situation it is reason to believe that most of us would apply a learning process, strongly inspired by behaviorist-based pedagogy. Insisting on applying a pure Constructivist based pedagogy for the described situation requires an uncompromized faith in Constructivist learning theory.

«Constructivist» example:

Another example, which can serve to illustrate an extreme situation requiring a very different pedagogical approach can be the task of ensuring that a group of students acquire competence in managing and participating in projects. In this case we can imagine that all the students have long working life experience and have frequently, in the past, been frustrated by the fact that most project work they have been involved in is not very satisfactorily conducted. To correct this, the students have attended a course in Project Management organized by a local college and are prepared to follow this during a period of three months. Obviously, this situation is very different from the pilot training example above. The students are all very motivated and prepared to put in a considerable effort to learn and thereby avoid future frustrations when involved in project work. And further, the duration of the learning process is relatively long, the consequences of failure are not particularly great, the curriculum is not very precise and the issue not well structured. As opposed to the conclusions related to the previous example, most of us would in this case be very confident that the learners will take sufficient responsibility for own learning, making strong efforts to pull out necessary information from the supporting learning environment. And hence recommend a Constructivist based pedagogy.

Retrospectively it can be concluded that the experimental conditions, at the early stages of the PedTek project should have provided for variations in the test cases and collection of empirical data, enabling testing of the hypothesized correlation between the critical variables and suitable pedagogy. However, this conclusion would not have been possible, or at least hard to make without the experience gained from the PedTek project. Without sufficient empirical material allowing this, the required experiments will have to be left for further research.

3.2.2 Intelligent software agents

Proposing adaptive pedagogical solutions raises, in addition to theoretical, also practical questions related to how, adaptive systems can be implemented within acceptable cost effective frameworks. Adaptive pedagogical solutions imply less standardized and more tailor made learning processes requiring information about individual students or groups of students. Without resource restrictions this can be realized by allocating individual tutors, guiding students based on information of background and learning progression of individual students. However, in most practical situations this will have unacceptable cost efficiency effects.

With the present progression in the development of so called intelligent software solutions, the task of keeping track of individual learning progressions and providing each student with individually designed learning processes may be practically feasible.

> «An agent is a software thing that knows how to do things that you could probably do yourself if you had the time.» (Kaur A. 2000)

By considering, both the critical variables and individual learning progressions, Intelligent software agents could be applied for partly automation of the monitoring and design of adaptive solutions.

> «The agent will autonomously monitor the progress of the group project, suggest ways in which the students can act to improve progress and enhance the communication between members of the group. Each student working on the project will have an individual agent, operating in the background, watching progress, measuring it against the plan, and taking remedial action when necessary.» (Whatley et al. in Kaur A. 2000)

In this context it is important to emphasize that applying intelligent software agents is nothing more than providing the human tutors with a support system, easing the task of keeping track of individual students.

3.3 The 4-component structure

The 4-component structure of the NBLE (Ibid p. 50), represent a model for research discussions and practical development work. At the initial stages of the PedTek project, the 4-component NBLE model was found convenient to use as a reference for the discussions and considerations among the developers and researchers. But as the experimental development process progressed, the model «survived» and the 4-component NBLE model represents a useful conceptual framework, also for future practical and theoretical approaches to net based learning issues. Practitioners and theoreticians have a convenient reference for planning, thinking and communicating point of views during development work and analysis. The 4-component model does not, however imply that the specific content of each component is determined and controlled. As discussed earlier (ibid. 2.2.4.1 – 4) each of the components, Pre-produced learning material, Learning Management System, Supervision and exercises and Face to face meetings and workshops, can have from very little or none to a very comprehensive content. Ideally, NBLE solutions should allow the learners to pursue different and individually adapted learning paths, determined by the critical variables (ibid. p. 71). With future solutions, «Intelligent software agents» (ibid. p. 74) may be included, as part of the model, to provide better monitoring of the learners progression.

The discussions of each component in the next sections of this chapter represents a combination of advice and guidelines for realizing and implementing flexible learning processes, based on the 4-component NBLE model, and presentations of research findings and results. Advices and guidelines are not sufficiently detailed, to qualify as a handbook in designing and implementing net based learning systems and is not meant to be. Care is taken to formulate the presentations with the objective of providing valuable advice for developers and designers involved in practical projects aiming at implementing net based learning systems. If the presentations and discussions also can serve this purpose it is obviously an advantage.

3.3.1 Pre-produced learning material

With the two courses used for experimentation, pre-produced learning material consisted mainly of textbooks defined by the curriculum, articles and notes related to the terminology of the subjects to be learned. This material was kept relatively unchanged during the six years of experimentation. For the last three NBLE prototypes, 2000, 2001 and 2002, three video-triggers were introduced as additional parts of the learning material (Ibid. p. 51). The video triggers were specifically produced to «trigger» off reflections and thinking related to issues of Project management and Systems development and in correspondence with principle of PBL and CL. In designing the scenarios of the video triggers, care was thus taken to not provide answers to how various problems should be solved. The video triggers presented scenarios from situations in the fictive enterprise, Rørleggerservice AS. (Plumbingservice Ltd) in connection with the introduction of a new computer-based information system. Apart from the standard textbooks, all the pre-produced learning material, including the video triggers could be loaded down from the LMS, but the videos were also made available to the students on cd-roms.

Experience from other colleges and universities indicate that the amount of material included in the Pre-produced learning material component varies considerably. In some cases very little pre-produced material is included, whilst in other cases the pre-produced learning material constitutes a major part of support for the learning process. At the Open University of Malaysia (OUM), with 7000 on-line students the learning model applied makes extensive use of pre-produced learning material.

> «..learners are provided specially designed print-based materials which constitute almost 60% of their learning and this is supported by face-to-face meetings which are held once a fortnight.» (Kaur A. 2002)

Retrospectively it can be concluded that the pre-produced learning material should have been defined in less detail in order to provide optimal support for PBL and CL related learning. By being very specific in defining the curriculum, some constraints where enforced on the students motivation and enthusiasm for involvement in a reflecting, constructivist learning process. However the balance between over-structured and under-structured learning material is delicate. The experimentation results indicate that some students frequently experienced a conflict between their expectations of freedom to define their own learning goals and learning process and the relatively well-defined learning material. The majority of these students were the most independent and motivated learners. Other students, the less independent and less motivated, wanted more well structured learning material. In particular the video-triggers, could be confusing to the less motivated students in the sense that they did not present «the right solution». Applying less well-defined learning material for these less motivated students obviously makes their learning process more difficult unless the pedagogy is adapted to their particular situation and needs.

The results from the questionnaire survey indicates that approximately 90% of the students found the recommended textbooks useful for the learning process, but only 60% thought that the video-triggers were useful. The majority of the students, considering the video-triggers to be useful, also expressed a positive attitude toward the PBL and CL based pedagogy and the overall quality of the NBLE based learning process. Based on this it can be concluded that the degree of details of the pre-produced learning material should be related to the pedagogy applied, which again, to some extent, is determined by the critical variables (ibid. p. 71).

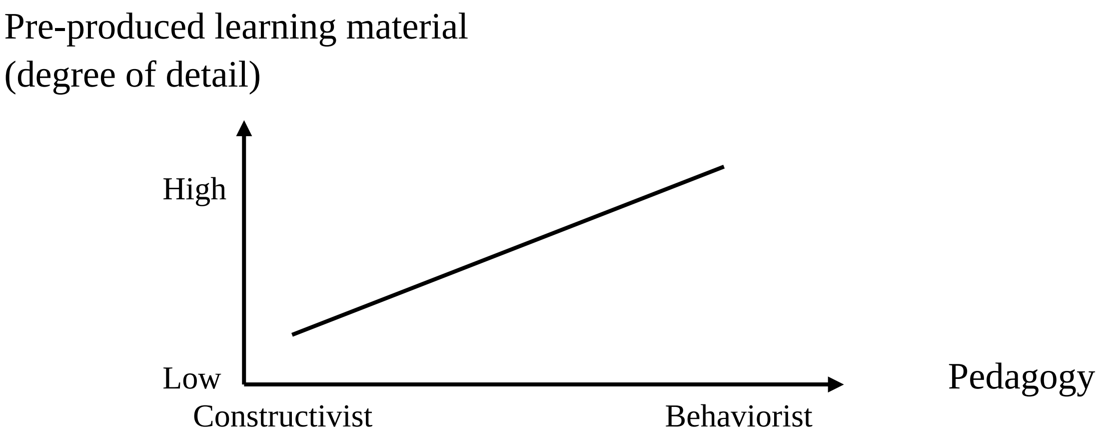


Fig. 3.2

Pre-produced learning material and pedagogy

3.3.2 Learning Management System (LMS)

A learning management system is pr definition required for a net-based learning environment. Without a LMS we may still have a well functioning learning environment, but it will not be net-based. The increased availability of the Internet and in particular the www has been one of the major driving forces behind the development and implementation of flexible learning programs. And at the start of the PedTek development, the developers' enthusiasm, related to the potential of the Internet was a major driving force. The expectations to and belief in the potential of web-based solutions was high, even if we already at that time clearly saw problems and challenges, especially with respect to accomplish optimal combinations of technology and pedagogy. During the course of the experimental development process, large efforts have been made to utilize, what we still believe is a large potential of web-based support systems. However, the experience from six years of experimenting indicates that we still have a way to go before, what we still believe is the potential of LMSs, is utilized properly. As the experimental development progressed it gradually became apparent that software applications, representing web-based support systems, not played the role in the learning environment as we hoped and expected.

Results from the questionnaire survey conducted among the undergraduate students indicates that approximately 90% of the students spent less than 2 hours pr week using the Learning Management System, ClassFronter. And consequently the majority of the students, 60 - 70 %, found none of the functions of the LMS particularly useful and beneficial for the learning process.

It can be concluded that the Learning Management System has not had the significance for the learning process we expected it to have. There are probably several reasons for this. Firstly, the difficulties in initiating activities and dialogues, in the web-based system, gives rise to a vicious circle. When activity and interesting dialogues are absent, the motivation for using the system is utterly reduced. And the responsibility for initiating activity, and thus breaking the vicious circle, is mainly resting on the supervisors and mentors and not on the students. By refraining from using the system, because the students were not very active users, the supervisors and mentors are to blame for the low frequency of use. The use of the web based support system, during the experimentation, represents little more than what could be achieved by using ordinary home pages, design with Front page, and traditional e-mail based on a standard browser. This would probably have the same effect as applying a licencensed product as for example ClassFronter or WebCt.

Experience from similar tests and applications of licensed LMS, at the Oslo University College, by Leikny Øgrim and her colleagues, indicates that the key to success is to include the system in the ordinarily activity on the campus, as a real arena for meeting and information. If the students, by using the licensed system find that they are provided with vital information, also for none course related matters, they will gradually grow accustomed to including the system as an integrated part of the college activity.

Secondly, the lack of activity in the web based support system is probably also due to the layout, user interface and functionality of the LMS. The design used for the last three versions of the NBLE prototypes during the experimentation is presented in the figure below. The layout is presented in its original form, with Norwegian text.

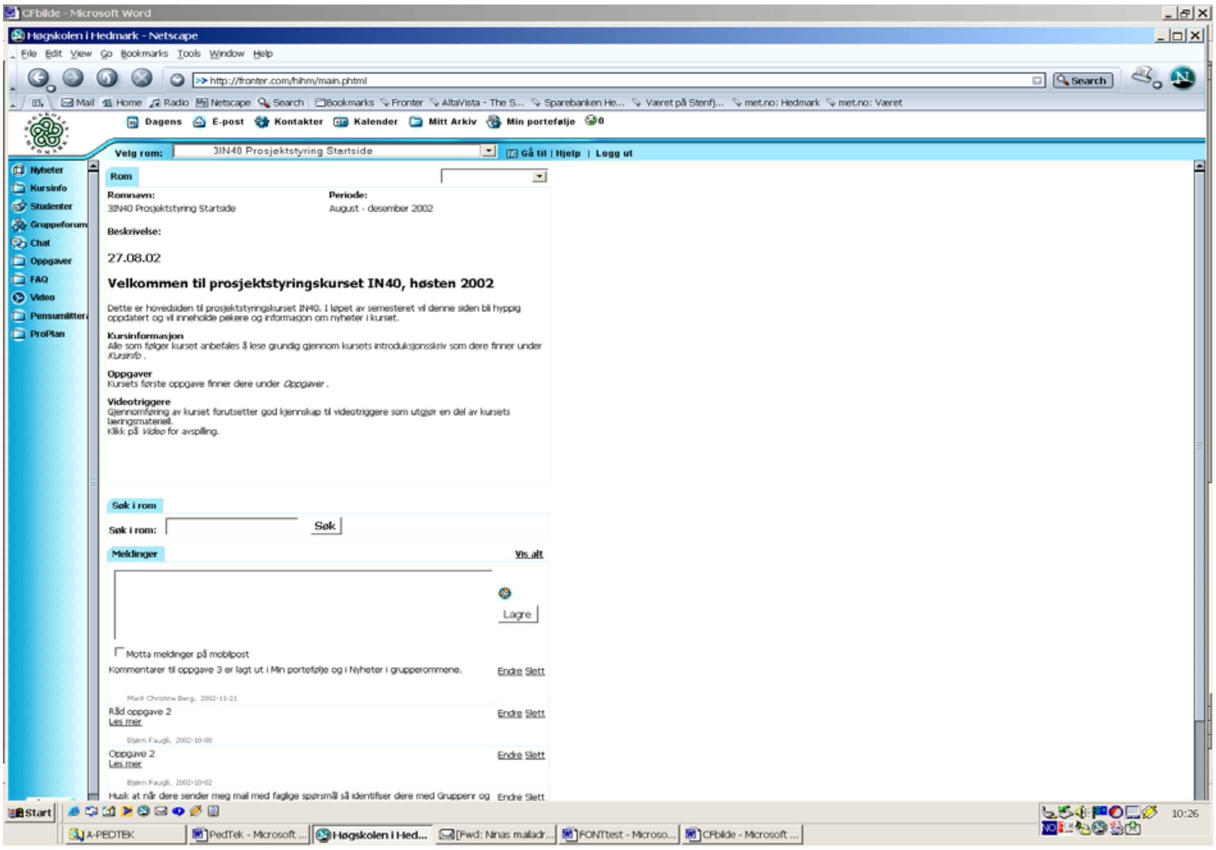


Fig. 3.3 Layout of the user interface in ClassFronter

In Europe, LMS of some kind is used to a varying degree for supporting on-line educational programs by most higher educational institutions. The type of systems varies from self-developed systems to commercially available standard systems. In Norway, ClassFronter is by far the most commonly used commercial system with systems called LUVIT, IT's learning, First Class, Kark and WebCt following some distance behind (Paulsen M. 2002). In the above ranking it is interesting to note that In-house developed systems are ranked only second to ClassFronter. The experience from the use of the different systems does not seem to vary significantly. For most applications the functionality of the LMS seem to mainly be to efficiently provide information and learning material and pedagogical considerations are to a large extent lacking.

> «LMS systems are usually not used for development of course content. A broad range of external tools is used to develop the content before it is published in the LMS system» (Web-Education Systems in Europe. Paulsen M. 2002).

A common critique against the presently available LMS, from users throughout Europe is also that the systems need to be integrated with other systems in the educational organization and in particular the integration between the LMS and the students' administrative system and systems handling the economy seem to be poor. (Paulsen M. 2002)

The layout and functionality presented in fig 3.3 and applied for the prototypes using ClassFronter, can be characterized as relatively static and is not promoting the system sufficiently or enquraging the students to use the system. By not succeeding in creating sufficient activity in the web-based support system, it may be worth looking at other disciplines involving similar challenges. With the design and functionality applied during the PedTek experimentation, it was to a large extent assumed that the students would find their way «into» the system, retrieve information and initiate discussions, simply based on enthusiasm of learning. It was assumed that the presence of an arena, with learning «products» in the «shelves», would be sufficient. When this turned out to not be sufficient, it is likely that we should have turned to professionals in public relations and marketing of products, to learn more of how products and services should be made visible and sold to both passive and active shoppers.

Based on this a «shop window» metaphor is introduced, to exemplify how the web based support system can be designed to ensure that the users, the learners, attention is drawn to the contents of the support system. Apart from very rare situations, with exclusive and well known products, shop owners are not assuming that the customers are entering the shop, prepared to take considerably trouble to search for products hidden on the shelves, inside the shop. They are displaying samples in the shop windows in order to draw the customers' attention to what kind of products they can expect to find if they enter the shop. The design of LMSs is, naively based on this latter assumption. By adapting principles from shop windows presentation of products, representing a more dynamic functionality, it is reason to believe that the use of LMS will increase.

By pursuing the idea of the «shop window» metaphor further it is obvious that the passive nature of a LMS, represents a considerably weakness. Even with a more dynamic «shop window» based solution the users are required to take the initiative and necessary actions to get inside and search for information. By designing a more active system, automatically contacting the users by e-mail, SMS or by other modern electronically communication means, when new and interesting information is available, it is likely that the efficiency of the system is enhanced. It is reasons to believe that a more personalized and adaptive LMS would be beneficial and enhance the user friendliness of the system.

3.3.3 Supervision and exercises

Supervision and exercises was throughout the experimentation, based on Constructivist learning theory and corresponding pedagogical principles related to PBL and CL. A variety of different solutions were tried out within this framework, ranging from well-defined exercises with relatively precise solutions to open solutions where the students had to define their own learning goals. With all the experiments, students were at all time required to work in groups and with few exceptions supervision was conducted toward the whole group. Only in very special cases and circumstances, supervision of individual students was conducted. The experience gained from this process, during a period of six years, clearly indicates that ensuring collaborative activity and not only coordinative activity in the groups, between groups, and between groups and external peers or supervisors is difficult. And further, it is difficult to know, retrospectively, how to characterize the particular group activities, which took place.

> «We define collaborative instruction to apply to all methods in which teachers and students abandon their traditional classroom roles in favor of more collegial roles as collaborating learners. A critical feature of such methods is that not only the teacher but all students actively participate in the production and presentation of knowledge.» (Abercrombie, 1969 in Koschmann T. 1996)

It is, despite this relatively broad definition, some uncertainty attached to the determination of to what extent a group activity fully qualifies as «pure» collaborative learning. This uncertainty and corresponding efforts to initiate collaborative learning activity represented a never-ending concern during all the experiments. The same uncertainty was to some extend also present with respect to the PBL based approach. However, by not attempting to initiate PBL in its purest and most orthodox form, we are more confident with the conclusions and experiences and the conclusions are not committed to narrow definitions of PBL and CL. The challenges involved in evaluating what is «going on» in computer conferencing applications have been a major concern for researchers during the past decades. In 1993, Mason R. discussed various methodological approaches to the evaluation and based on investigations of previous evaluation projects, concludes that

> «The most obvious data available to conferencing evaluators – the transcript of all conference interactions – is paradoxically the least used. There are astonishingly few comments, let alone analyses, in the literature of this central core of the whole enterprise». (Mason R. 1993)

Investigation of the written dialogues available is obviously an interesting approach, but it assumes that the dialogue transcripts reflect how the learning process has progressed. Problems related to this approach, when evaluating collaborative learning processes are that the transcripts seldom indicate what kind of communication have been going on between the students and oral communication is excluded in the transcripts.

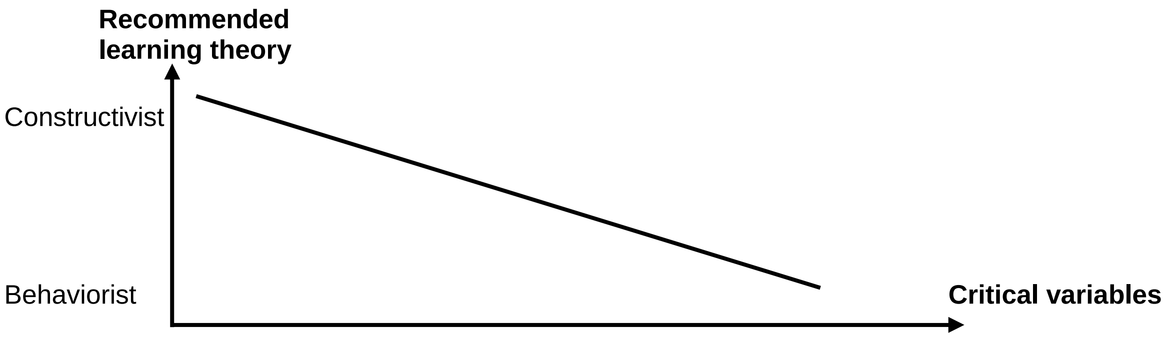
> «However, the analysis of the teleconferences did not indicate that the learners participated collectively in the reconstruction of knowledge, as the majority of the messages were independent.» (Mason R. 1993 in The Najaden Papers on Collaborative Learning Through Computer Conferencing)

With solutions, based on a combination of PBL and CL, it can, despite the uncertainties mentioned, be concluded that care must be taken to provide the students with exercises and supervision, carefully balancing structure and freedom to choose approaches and solutions. Well-structured exercises and precise supervision and guidance will limit the process oriented learning, reducing the work with exercises to what is comparable with conducting several successive exams. The students will then concentrate all effort in a short period before deadline and then wait until the next deadline before getting engaged again. On the other hand, ill structured exercises and imprecise supervision will easily increase the frustration among the majority of the students. Under these conditions only the «best» survives and benefits from the learning process. The balance between these extreme situations represents a delicate challenge. In situations where the supervisors have to choose between the two extreme alternatives, the temptation to choose the most structured approach is hard to resist. The option of avoiding frustrated and even hostile students is preferred even if the price is reduced learning outcome for the students. In addition to this subjective based tendency of most supervisors, it should also be added that, objectively, it is a reason to avoid frustrated students, since these students are likely to be less motivated and less interested in doing their best and hence likely to achieve a satisfactorily learning outcome.

Experience with different supervisors during the course of experimentation, indicates that the PBL and CL based solutions tried out are even more vulnerable to the competence of the supervisors in the subject to be learned than traditional solutions. Using the NBLE solutions with PBL and CL do not represent an easy way out with respect to deliver efficient educational programs of high quality. In particular with less structured and «open» solutions it is required that supervisors or mentors are able to handle questions and approaches from students, which require a comprehensive insight and competence in the subject. With traditional lecture based learning processes, a lecture can often «get away with» having sufficient knowledge to be able to answer a limited range of questions in the lecture theatre. With PBL based learning processes the supervisors must be able to answer and respond to a wide range of questions, also extending outside the curriculum.

Taking into account the uncertainties involved with respect to whether the pedagogical solutions really where PBL and CL, it can be concluded that the solutions used are reasonably successful. *The survey conducted among post graduate students having been employed as programmers or systems developers for the past one to three years shows that 92% considered the PBL and CL based pedagogy applied in the experimental courses, to be good or very good compared to a traditional lecture based pedagogy*. Also with reference to the Learning outcome of the NBLEs there are no indications that the pedagogical solutions, no matter how they can be characterized with respect to «pure» PBL or CL, are unsatisfactorily. Even if the majority of the students indicated that the applied pedagogy was successful, there is a significant correlation between those expressing the most positive attitude towards PBL and CL, and those with high motivation for learning. It is reason to conclude that the learning theoretical basis of the pedagogy applied should be related to «values» on the critical variables. Adaptive solutions are required. But the application of Behaviorist oriented approaches does not imply that collaboration is excluded. From the results of the PedTek experimentation and comprehensive studies in the field of Pedagogy and Psychology there are strong indications that learning is very much a social process.

> «We see that human cognition aspires to efficiency in distributing intelligence – across individuals, environment, external symbolic representations, tools, and artifacts – as a means of coping with the complexity of activities we often call «mental»….. a principle aim of education ought to be that of teaching for the design of distributed intelligence.» (Pea R. D. 1993)



Learners motivation: **High**
Learning culture: **Well developed**
Consequence of failure: **Small**
Duration of learning process: **Long**
Type of curriculum: **Ill-structured**

Learners motivation: **Low**
Learning culture: **Poorly developed**
Consequence of failure: **Large**
Duration of learning process: **Short**
Type of curriculum: **Well-structured**

Fig. 3.4
Recommended learning theory as a function of values of critical variables

The graphical presentation in fig. 3.4 of the relationship between Recommended learning theory and critical variables is very approximate and only to be considered as an indication of a tendency. The presentation merely serves as a convenient way to illustrate how extreme values on the critical variables effects the recommendation of what learning theoretical basis to apply for the pedagogical solutions. We have no evidence or data, neither to indicate more precise values on the variables nor to claim that the relationship is linear, as indicated in the graph.

Throughout the experimentations, the students always worked in groups, and no individual activity was formally recommended. A consequence of this was that the marks or evaluation of mandatory exercises were collectively for all members of the same group. A frequently framed complaint from the students was that «free passengers» where allowed in the groups. To compensate for this, individual written exams, were introduced by the end of the learning process and term, allowing individual students some space for showing their individual «level» of competence.

3.3.4 Face to face meetings and workshops

During the early stages of the development process, attempts were made to organize the learning process, without physical meetings between students and supervisors. The very first prototype tested in 1997, used videoconferencing, as a substitute for an initial workshop with face-to-face meetings, and the result was not very satisfactorily. The story told in appendix 4, (An odyssey into the field of distance education and flexible learning), is reflecting some of the experiences from this attempt. The motivation for trying out a «face to face free» solution was that this represented the most flexible alternative, not requiring the students to be on campus. But the test clearly indicated that the students were not particularly pleased with only getting the opportunity to meet with the supervisors through a videoconferencing system. At this stage the conclusion was relatively clear. Meeting with the students, face to face, was a prerequisite for initiating satisfactorily flexible learning processes. This conclusion was based on the state of the art of videoconferencing technology in 1997, and in addition, we had little experience with this technology. Videoconferencing was not since then included in the experimentation as a substitute for face-to-face meeting. But, in different context, involving traditional lecture based learning processes, we have gained considerably experience in this field, and the use of videoconferencing is now relatively successful. Improvements in the technology, by the availability of more «user friendly» solutions, have played an important role. With the present state of the art in videoconferencing technology, it is very likely that some of the face to face meetings, can be substituted, but the first meeting between students and supervisors is the most critical, and probably still worth the investment of arranging as a face to face meeting.

With the versions on NBLEs tested, in 1998 and 1999, face-to-face meetings were arranged at the start of the learning process. The main emphasis in these meetings was to provide the students with basic information and knowledge of the curriculum based issues in project management. But neither of these meetings was very successful. The students were provided with curriculum-based knowledge, but throughout the learning process, the majority failed to comply with the requirements of the PBL and CL based pedagogy. Analyzing the feedback from the students obtained by questionnaire surveys and through extensive interviews and participatory involvement with the students, made it clear that an initial presentation of the pedagogy of the learning process was required. Leaving the students on their own, with a large amount of curriculum based knowledge, but unprepared for the untraditional learning process was close to what can be characterized as a catastrophe.

The main conclusion, with respect to the fourth component of the NBLE, «Face to face meetings and workshops» is that preparing the students for the planned pedagogical solutions, especially when they not are accustomed to this pedagogy, is of vital importance for the success of the following learning process. And, unless it is for various reasons, impossible or very difficult to organize the first meeting as «face to face», the effort of physically gathering the students, is a cost effective investment.

During the tests of the first four prototypes, from 1997 to 2000, only one initial meeting with the students was organized. It can be concluded that this is within a satisfactorily framework, but additional face to face meetings are clearly improving the learning conditions. The explanation of this is probably more related to psychological effects than effects with respect to concrete enhancement of knowledge. The experience from six years of experimentation with NBLEs, indicates that many students are uncomfortable with little face-to-face contact with supervisors, despite the fact that they work collaboratively and frequently have face-to-face meetings with other students in their CL group.

> «Although we believe a strong case can be made for the use of computer-augumented interaction in the classroom, the reader should recognize that it would be undesirable to use it as the sole means of communication.» (Koschmann T. 1996)

But even if excluding face-to-face meetings still represent a problem, a tendency that this problem is decreasing can be observed. In particular, this is valid for students with previous experience with similar learning process. As the experimental development process progressed, since the start in 1997, an increasingly larger proportion of the students attending the test courses, had previous experience with similar learning process. Especially the experiments conducted during the past two years have involved students of this category. With the most recent test, involving a Systems Analysis course, used in the spring term of 2003, the students had been through a similar learning process once in the Systems Development course in the fall of 2002. The attitudes of these students clearly indicate that they are more comfortable with the untraditional learning process than earlier students.

The reasoning above may have considerable implications for future designs of NBLE, in the sense that an increasing proportion of the students attending flexible courses, employing NBLE will be accustomed to and prepared for the learning process, and the learning process may not longer be qualified as being untraditional. This brings up new situations and conditions, which may be relevant for many of the conclusions in this report, in particular with the significance of conducting face-to-face meetings and workshops. To what degree it is necessary to include face-to-face meetings during a learning process will to a large extend have to be determined by the supervisors or teachers, more or less intuitively, during the course of the process.

> «Experienced educators must exercise some judgment in identifying time and places where computer-mediation can facilitate the process and where it might interfere.» (Koschmann T. 1996)

With more experienced students, representing a new culture, with respect to using technology as learning support systems and PBL and CL based learning processes, the running of flexible learning processes will probably be a more straightforward enterprise.

4. Organizing and delivering flexible Net Based Learning Systems

The previous chapter focused on issues related to pedagogical and technological considerations and challenges involved in the design of NBLEs. The objective of the present chapter is to discuss considerations and challenges involved when taking on the task of realizing and implementing a NBLE in a real educational situation involving the organization of the educational institution. This discussion is based on the design considerations presented in the previous chapter, but shifts the focus to the particular challenges involved when an educational institution are using the solutions in a «real life» context. The discussion is particularly related to the tensions between pedagogical, technological and organizational aspects (Fjuk A. 1998) in real situations. To some extend the discussion is suggesting means of «relieving» some of this tension, based on the experience gained from the experimental process conducted during the past six years as part of the PedTek project.

4.1 Untraditional learning processes and traditional organizations

During the experimental development process in PedTek, an untraditional learning process was introduced in the traditional organization of HUC. The HUC bureaucracy, as with most other colleges and universities, is well adapted to serve educational programs based on traditional lecture based learning processes. Allocation of resources is closely related to these traditional tasks. The teaching programs and plans are prepared well in advance with the allocation of lecture theatres, arrangements of exams in traditional settings and providing the students with the same type of information as have been used for the past decades. And even if the lecture based learning processes, to an increasingly degree, are relying on technological solutions for presentations in lecture theatres and some learning material on the web, these learning processes are not particularly vulnerable to the efficiency and availability of the technology. With PBL and CL based learning process, most of the traditional planning procedures and functions becomes less useful and have to be changed. If a video projector for a power point presentation is failing during a traditional lecture, it can almost always be substituted by plastic foils on an overhead machine or even by the old fashion whiteboard or blackboard. And if the web server is down, or the course material is not available for shorter period of time, it has rarely catastrophic consequences. With net-based learning environments the situation is different and a much higher degree of attention is required by the technical help desk. During the experimental development the new and untraditional learning process, frequently challenged the organization at HUC, causing frustration for both the developers and the administrative staff. *The questionnaire surveys conducted among the undergraduate students indicates that about 30% of the students are dissatisfied with the way HUC have been administrating the courses and only 16% are satisfied or partly satisfied.*

4.2 Twin-level systems development

As pointed out previously, a development process of this nature is not terminated, even though, the formal project is concluded and closed.

> «It understands systems development as a process that does not stop when a development project stops. It comprises development and use.» (Kautz. K. 1993)

Experience gained from the field of systems development during the last decades, indicates clearly that emphasis must be on both technical, people related and organizational issues.

> «A common misinterpretation among educators who are not familiar with a systems approach is that it is possible to benefit from introducing technology into education without doing anything to change the other ways in which education is currently organized. They think that by moving cameras, computers and microphones into the

> classroom, schools, universities, and training departments, they can increase enrollments, provide new curricula, and save money without doing anything else. According to this view, once the technology is in place, there is little else to be done except to let teachers get on practicing their craft as they have always done.» (Moore and Kearsley, 1996. From Fjuk, Annita 1998)

Developing NBLE solutions, represents a type of systems development with the goal of implementing what a little imprecisely can be defined as a «pedagogical computer based information system» (ibid. p. 33). The experience gained throughout the experimental process in PedTek, indicates however, that focusing on the NBLE as a computer based information system represents a too narrow perspective on systems development in this context.

> «Cole and Engestrøm discuss whether technology can be a catalyst for educational change. Concerned with this, they suggest that it is not enough to consider individual instruments. Rather, any analysis must consider the whole complex of educational activity.» (Fjuk A. 1998)

Larger part of the educational system must be included in the development process and based on this it is suggested that systems development, involving NBLE in an educational institution, should be conducted at two levels. The first level includes the NBLE and the immediate surroundings and the second level includes the first level, implemented in an expanded organizational environment. Sound principles of systems development emphasizes that development must involve the technical system, the organization and the individual users as equally important elements. Based on this perspective, a twin-level systems development approach requires that particular attention is paid to which part of the total system should be involved in the development at each level.

At the first level, systems development can be conducted relatively isolated from the organization of the educational institution. The challenges involved in the integration of the system in an organization can be preliminary handled by the developers as part of the development work. At this level, larger part of the NBLE is to be considered as the technical element of the information system, the organizational element will be the learning process and the users are represented by the students and the supervisors. The main development objective of the first-level-process is to produce a solution with optimal balance of pedagogical and technological factors. When a satisfactorily degree of stability is reached for the first-level-solution, the second level of systems development can be approached.

At the second level, the solution, resulting from the first level development, is considered as the technical element of the total system. The organizational element, at this level will be the organization of the educational institution and the users will be the administrative and technical support staff. A graphical presentation of this twin-level systems development is shown in fig 4.1 below.

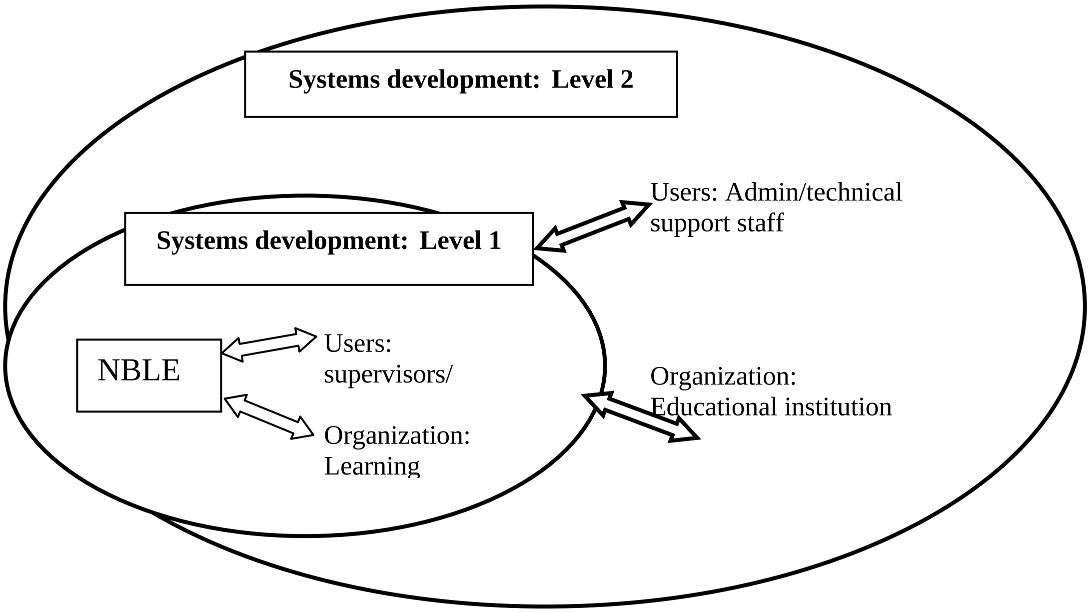


Fig. 4.1
Twin-level systems development

In one perspective, the NBLE can be considered as the product of the development activity whilst the process oriented results are equally important. Approaching the process of developing computer based information systems with successful results can advantageously be based on dialectical principles.

> «Dialectic theory has a strong position within the Scandinavian critical tradition in academic systems development (Mathiassen, 1981; Ehn, 1988; Stage, 1989; Bjerknes, 1989; Øgrim, 1993), since dialectics can

> support both multi perspective thinking and the understanding of change. The belief of this tradition is, that systems development is an uncertain and complex process, a process that can only be partly granulated and planned in detail.» (Fjuk A: 1998)

A large part, possibly the major part of the experience and knowledge gained by conducting the development process in PedTek is not even «visible» and presented in this report. These experiences, knowledge and skills are embedded in the organization, as organizational learning, represented by a more conscious relationship to the problems and challenges involved in delivering flexible net based learning systems. Hopefully and probably, the result of this will be that the organization at HUC in particular but educational institutions in general now are in a better position to design, organize and deliver flexible net based learning systems. And further, that the effect has inspired and initiated a conscious and even an unconscious learning process, among the faculty and staff at HUC.

Introducing a computer based information system, with considerable implications for the host organization, requires careful planning and the involvement of the users in the process are important in several respects. Firstly, the users should be involved for democratic reasons. Introducing or changing computer-based systems may have considerable effects on the members of the organization and these should thus be involved in the process. In the Scandinavian countries user participation is required by law. Secondly, the users should be involved, simply because successful systems cannot be developed and implemented without active participation and contribution from the potential users. In this context it is important to specify what is meant by successful systems. As opposed to a common conception of the term successful, it represents a characteristic, which cannot be objectively and absolutely defined. The definition is to a large extend dependent on the background and perspective of the observer. This has considerable implications for the introduction of computer based information systems in organizations. The following formula, illustrates this in a simplified way.

> Success=f (Quality, acceptance)
> (Methlie 1990)

Verbally this can be expressed as: Success of something is a function of or depends on both the quality of the «thing» and how it is accepted by the users. Expanding on this, it means that the success of introducing a computer based information system depends on both the quality of the system and how the system is accepted by the users. It may be obvious, but the most important aspect of this «formula» is that a system can be successful even if the quality is not the best as long as the users, for whatever reason, accept the system. And the key to acceptance is a development process with real and comprehensive user participation.

4.3 Organizational learning

Organizational learning represents a considerably challenge and it is suggested that the organizational learning process as a part of the systems development, should be explicitly related to pedagogical principles.

> «To reach a higher logical level in the cognitive process, conditions for reflections must be provided. Time for individual reflections can be provided by for example, writing or programming, ref. Naur (85), and for collectively, multiperspective reflections through discussions and confrontation of opinions. The process from the general to the specific can be supported by enquraging the project participants to apply experience from other disciplines (such as management, organizations, official regulations) to understand the specific situation in systems development.» (Øgrim L. 1993)

In most systems development perspectives and guidelines, the development process with user participation and organizational learning is considered a prerequisite for successful results. It is however, rarely suggested approaches to organizational learning explicitly based on pedagogical principles. In most cases it is assumed that user participation and organizational learning in some way takes place through involvement in the process and to some extent this is true. But with the nature of the systems development process, and in particular the «second level» of development introduced above it is suggested that learning should be organized systematically and based on principles from PBL and CL.

Analysis, to provide user requirement specifications and a proper understanding of the systems environment, as part of the systems development at the second level, may benefit from applying a modified Activity theory approach. In Fjuk and Smørdal (1997) it is concluded that:

> «The interrelation between individual and collective oriented action is important when it comes to understand and analyze the complexity of (collaboratively based) work. With basis in Engestrøm (1987) model of collective activity, we enrich the concept of collective action with Strauss' (1993) theory on action and interaction.»

Having terminated the major part of the first level of systems development, a reasonably stable NBLE, successfully combining pedagogy and technology can be introduced as the technological element of the second level information system. At this level, the users, represented by the faculty, administrative staff, library staff and the technical support staff, should be involved in the development project and organized in groups faced with tasks and real exercises, allowing collaborative learning processes to take place.

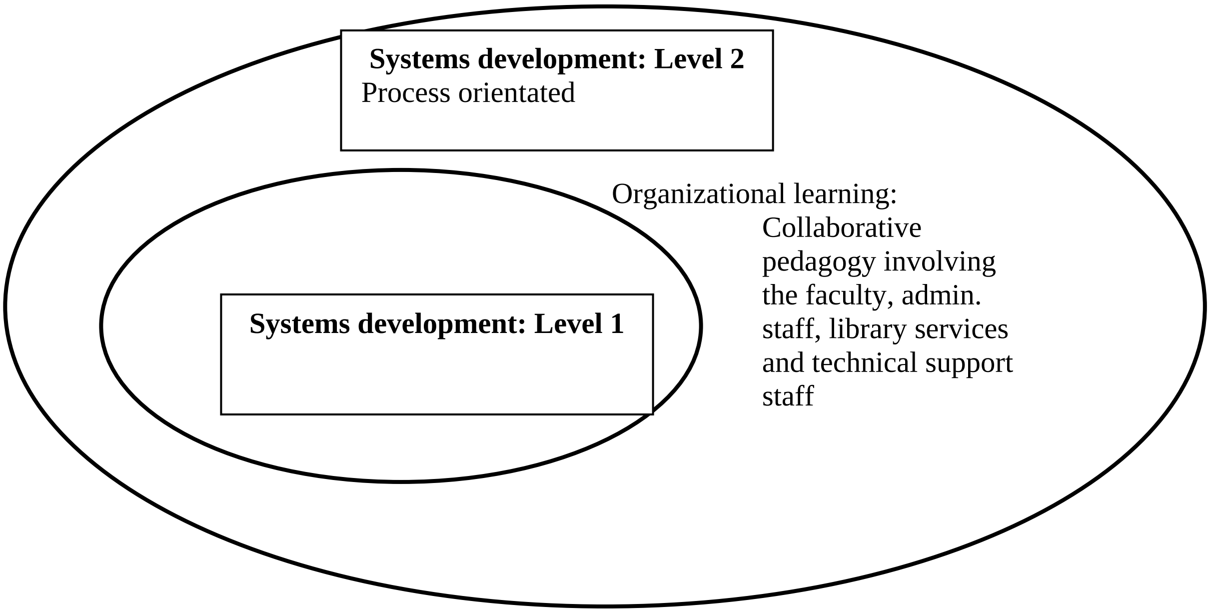


Fig. 4.2
Organizational learning at systems development level 2 based on Collaborative learning

In organizing projects, as an integrated part of a larger organization, a key success factor is also involvement of the management. The management must have an «ownership» to the project and thus ensuring that all parts of the organization is involved and allowed to allocate time and resources for involvement in the project. For educational organizations, not very experienced with organizing and delivering net-based educational programs, involving untraditional pedagogy, the attempts should clearly be defined as systems development projects and not considered as just a trivial expansion of the traditional learning process. By conducting the introduction of new educational programs, as systems development projects, and conducting these projects in appropriate ways, it is ensured that user participation in both planning, analyzing the user requirements and implementation has an increased possibility of being successful.

5. Conclusions, hypothesizes and recommendations

5.1 Conclusions

When concluding on an R&D process, spanning many years, the desire to come up with and present new and sensational conclusions, showing that the results contributes considerably to the knowledge of the research community, is strong. But such results are rare. Development of new systems is a time and resource consuming activity and not at least, puts the developers patients to a considerable test. Resisting the temptation of presenting quick results in order to please the expectations from the surrounding professional environment is hard. The ability to cope with this temptation is a major explanation of why the presentation of results from the PedTek project is long overdue. As the experimental development process progressed, our rate of learning accelerated, thus making it hard to terminate the process and present results. However, this is admittedly, not the only explanation for the delayed termination of the project. Retrospectively it can be concluded that the experiments could have been conducted more efficiently within the same resource framework and hopefully, this insight will help us to improve R&D activities in the future.

The results from six years of experimenting with net based learning solutions in PedTek cannot be characterized as spectacular or sensational. In many respects, the test results have merely confirmed what we knew, or at least thought we knew, in advance. Some of the efforts may seem a little unnecessary and a waste of resources. However, the confirmation of what we «knew» is in itself a significant result. The difference between «think we know» and «to know» is especially important when it comes to provide a background for decisions on how to invest time and resources in the future. Leaving the discussion of spectacularity of the R&D results, any project should at least present conclusions of the success with respect to predefined goals. With the PedTek project the objective of the development activity was to:

«Design an efficient and flexible Net Based Learning Environment (NBLE) for off-campus students, applying pedagogical principles based on Collaborative Learning (CL) in combination with Problem Based Learning (PBL).»
And the objective of the research activity was to:
«continuously acquire knowledge as feedback in support of the development process and to gain general knowledge in the field of NBLE.»

With reference to the predefined development goals it can be concluded that Hedmark University College (HUC) in particular and readers of this report in general, now should be in a better position than before to provide efficient net based education programs for off-campus students applying PBL and CL based pedagogy. In 1998, Annita Fjuk concluded in her Phd thesis that it is still a long way to go before we find good solutions for CSdCL. This conclusion still holds even if we have moved a little further along the path since 1998. The PedTek project has to some extend contributed to this by presenting relatively concrete guidelines for the design of NBLEs and by enhancing the organizational learning at HUC. But as also pointed out earlier the experimentation did not succeed in a comprehensive testing of CSdCL situations. Collaboration among learners, separated by physical distance was not tried out. All learners were on-campus students and collaboration among the students took mostly place through physical gatherings. Only collaboration with the experts, the supervisors and mentors were conducted through computer support without involving physical meetings.

The four-component structure NBLE, consisting of Pre-produced learning material, Learning Management System, Supervision and exercises and Face to face meetings and workshops, represents a convenient model for implementing learning processes for off-campus students. With designs based on suggested guidelines, the students learn more, with reference to curriculum based knowledge than with a traditional lecture based learning process. And combined with the flexibility, resource requirements and learners satisfaction the solutions are superior to the traditional, lecture based learning programs. In this context it should be noted that the Norwegian «Quality reform» suggests that reorganizing learning processes require that all institutions in higher education shifts emphasis from product orientation to process oriented learning. This must be taken into account when considering the resource requirements of the NBLE's because the implications of the Quality reform are, among other things, that all college and university courses in Norway, will face the challenge of implementing process oriented approaches in the future and thus, a comparison with the resource requirements of traditional lecture based teaching is becoming less relevant since this does not represent an alternative in the future.

As pointed out previously, a development process of this nature is never terminated, even though, the formal project is concluded and closed. A large part, possibly the major part of the experience and knowledge gained by conducting the development process in PedTek is perhaps not even visible and presented in this report. These experiences, knowledge and skills are embedded in the organization, represented by an enhanced conscious relationship to the problems and challenges involved in delivering flexible net based learning systems. It is suggested that in the future, the implementation of net based learning environments in organizations should be defined as a twin-level systems development project. The first level should deal with the combination of pedagogy and technology and the organizing of learning process with the students as users of the system. The second level should deal with the NBLE in relation to the administrative and technical support part of the organization, involving administrative and technical staff as users. Hopefully and probably, the result of this will be that the organization at HUC in particular and educational institutions in general, are in a better position to design, organize and deliver flexible net based learning systems in the future. And further, that the project has inspired and initiated a conscious and even unconscious learning process, among the faculty and staff at HUC.

With reference to the objective of the research activity it can be concluded that the feedback oriented part has been successful in the sense that it has continuously provided the development process with corrections, based on analysis results from the experiments. To provide precise conclusions with respect to the success of the more general objective of the research activity, «to gain general knowledge in the field of NBLE», is harder and must be left to the readers of this report to conclude on. However, some of the more obvious research results include the identification of a set of critical variables, providing a background for suggesting instructional design with adaptive NBLE solutions. By considering Learners motivation, Learning culture

Consequence of failure, Duration of the learning process and Type of curriculum it is hypothesized that pedagogy based on different learning theories should be applied.

As a final concluding comment it must be emphasized that the successful results of the R&D process may represent a paradoxical situation for higher education. In one respect, the availability of more flexible educational solution of high quality will strengthen and make higher education more available for larger parts of the population. However, in another respect, the same high quality flexible solutions, may result in undermining the role of the campus. By defining Learning outcome as a relatively narrow phenomena, related to curriculum-based knowledge the paradoxical situation is not apparent. But, by defining learning outcome in a wider perspective, including ability to interact socially, develop tolerance and solidarity, the undermining of the role of campuses as an arena for social learning is a serious problem. However, this is beyond the scope of this report, but should be taken seriously by the political authorities.

5.2 Hypothesizes and recommendations

The recommendations presented here is to some extent naturally overlapping with the conclusions above. What is concluded will inevitably indicate how the results should be used and what should be done in the future. But, with the risk of some overlapping descriptions, the recommendations presented are focusing on two paths of what should be further R&D activities. The first is recommendations of how to use the results in practical situations and the other is pointing out and suggesting a research path for the future.

Recommendations related to the use of the results in practical situations are that the implementation of net based learning environments in organizations not can be considered a trivial task. The implementation process should be defined as a proper systems development project involving two levels. The first level should deal with the combination of pedagogy and technology and the organizing of learning process with the students as users of the system. The second level should deal with the NBLE in relation to the administrative and technical support part of the organization, involving administrative and technical staff as users. And the systems development project should be considered as continuous exercises as long as the organization is involved with delivering flexible net based learning environments. Sometime in the future, we may be in a situation with sufficient knowledge and skills that enables us to handle this as a standard organizational activity, but until then it must be considered as a project.

Recommendations related to future research activity are based on insight in issues and conditions where we are in need of enhancing our knowledge. The PedTek experiments have given concrete results and a better insight in our shortcomings and lack of understanding of vital issues. Future research should particularly focus on testing some of the hypothesizes emerging from the PedTek experimentation.

The most obvious recommendation in this respect is to pursue the experimental path, started in PedTek and expand this to include a wider span of test cases in order to obtain more representative results. Test cases involving different curriculums and subjects should be included. In particular, it should be focused on testing the hypothesizes of the critical variables' effect on the pedagogical solutions. More comprehensive experimentation with CSdCL situations, with both learners and experts separated by physical distance is required to gain more knowledge. Development projects with the objective of finding more adaptive solutions should be attempted with the use of intelligent software agents. Other issues on the R&D agenda in the future involves the standardization of learning modules by the use of learning objects, enhanced understanding of what is required by a Learning Management System, in particular by applying modern multi media technology and the effect of cultural factors on the design and functionality of NBLEs. The last issue will be of particular interest as educational systems in the future are expected to be more internationalized.

References

Abildtrup Johansen, B., J. Rathe and A. L. Rathe (1997): *Mulighetenes barn i mulighetenes skole : en pedagogisk profil - fra idé til virkelighet,* [Oslo], Praxis forl.

Alter, S. (1992): *Information systems : a management perspective,* Reading, Mass., Addison-Wesley.

Andersen, E. S. (1994): *Systemutvikling,* Bekkestua, Nki.

Axelsen, T. and A. Finset, Eds. (1973): *Aksjonsforskning i teori og praksis,* [Oslo], Cappelen.

Bang, J. (1997): «Multimedier, interaktion og narrativitet : edutainment eller læring?» i Danielsen, O. et al: *Læring og multimedier,* Aalborg, Aalborg universitetsforlag**:** pp. 21-39.

Bannon, L. (1995): «Issues in computer supported collaborative learning», i O'Malley, C.: *Computer supported collaborative learning,* Berlin, Springer. 128: pp. 267-281.

Barnett S: M. Koslowski B. (2002): *Adaptive expertise: Effects of type of experience.*

Bates, T. (1995). *Technology, open learning, and distance education*, London, Routledge.

Beck E. (2002): «Participation is Not Enough», *Scandinavian Journal of Information systems.*

Breum, T. (1993): *Film : fortælling & forførelse : en grundbog om filmdramaturgi og manuskriptskrivning,* København, Frydenlund/Media.

Bjørke, G. (1996): *Problembasert læring : ein praksisnær studiemodell,* [Oslo], Tano Aschehoug.

Bjørgen I. (1999): *Det amputerte og det fullstendige læringsbegrep* (The amputated and complete conception of learning)

Bødker, S. (1996): «Applying activity theory to video analysis : how to make sense of video data in human-computer interaction», i Nardi, B. A.: *Context and consciousness : activity theory and human-computer interaction,* Cambridge, Mass., MIT Press**:** pp. 147-174.

Comte A. (1858): *The positive philosophy of Auguste Comte* (Translated and condensed by Harriet Marineau), Calvin Blanchard, New York.

Dahlbom, B. (1996): «The New Informatics», *Scandinavian Jounal of Information Systems*, 8 (2), pp. 29-48.

Denzin, N. K. and Y. S. Lincoln, Eds. (1998): *Collecting and interpreting qualitative materials*, Thousand Oaks, Calif., Sage.

Diesen, J. A. (1995): *Eit hugtakande læremiddel? : undervisningsfilmen i norsk skole,* Institutt for drama, film og teater, Trondheim, Universitetet i Trondheim.

Dirckinck-Holmfeld, L. (1990): *Kommunikation på trods og på tværs : projektpædagogik og datamatkonferencer i fjernundervisning,* PICNIC-nyt, Aalborg, Aalborg University.

Drucker P. F: (1980): *Managing in Turbulent Times*, William Heinemann Ltd. London

ECON (1994): *Behovet for komptanseutvikling i staten*.

ECON (1997): *Utdanning og fleksibilitet*, ECON-report 97:37, Oslo, ECON Senter for økonomisk analyse.

Ehn, P. (1989): *Work-oriented design of computer artifacts,* Stockholm, Arbetslivscentrum.

Ehn, P. (1993): «Scandinavian design : on participation and skill», i Schuler, D. and A. Namioka: *Participatory design : principles and practices*.. Hillsdale, N.J., L. Erlbaum Associates**:** pp. 41-77.

Elster, J. (1983): *Explaining technical change : a case study in the philosophy of science*, Cambridge, Cambridge University Press ; Oslo : Universitets-forlaget.

Eneroth, B. (1984): *Hur mäter man «vackert»? : grundbok i kvalitativ metod,* Stockholm, Akademilitteratur.

Engeström, Y. (1987): *Learning by expanding : an activity-theoretical approach to developmental research*, Helsinki, Helsingin yliopisto.

Ericsson, K. A., Krampe R. T., Teschromer C. (1993): *The role of deliberate practice in the acquistion*

Etzioni, A. (1964): *Modern organizations,* Englewood Cliffs, N.J., Prentice-Hall.

European Commision (1996): *The Economic Dimension of Education and Training in the Member States of the European Union*, Directorate General XXII.

European Commission, Gass J.R. (1996): *The Goals, Architecture and Means of Lifelong Learning*

Farazmand, A., Ed. (1994): *Modern organizations : administrative theory in contemporary society*, Westport, Conn., Praeger.

Faugli, B, Holden, G. (1998): *PedTek. Pedagogikk og Teknologi Statusrapport,* Høgskolen i Hedmark.

Faugli, B (1995): *Høgskolestudium i informatikk for bevegelseshemmede*, Oppdrag fra Det Kongelige Kirke- utdannings- og forskningsdepartement (KUF).

Faugli, B. (1998): *Høgskolestudium i informatikk for bevegelseshemmede, tilleggsvurderinger*. Det Kongelige Kirke- utdannings- og forsknings-departement (KUF).

Faugli, B., Haugen, A. O., Høyer, H. C. (1998): *Høgskolestudium i informatikk for bevegelseshemmede. Rekrutteringsgrunnlag*, Det Kongelige Kirke- utdannings- og forskningsdepartement (KUF).

Faugli, B., Fjuk, Øgrim (1997): *Prosjektnotat PedTek*, Høgskolen i Hedmark.

Faugli, B. (2003): *On-Line education and Traditional Organizations*, Full Paper. AACE conference: E-Learn 2003, Phoenix, Arizona, USA.

Faugli, B. (2003): *Evaluation of Learning Processes in general and Computer Supported Learning Processes in particular*, Full Paper. AACE conference: E-Learn 2003, Phoenix, Arizona, USA.

Faugli, B. (2003): *Evolution of Education and Computer support*, Full Paper. AACE conference: E-Learn 2003, Phoenix, Arizona, USA.

Faugli, B. (2003): *Knowledge-Based International Aid by ICT-Supported Learning Processes*, Høgskolen i Hedmark.

Faugli, B., Løfskog, A. (1998): *Kompetansebehov: En undersøkelse blant virksomheter i Värmland og Hedmark, Sluttrapport.*

Faugli, Fjuk, Øgrim: *Pedagogikk og teknologi for distribuerte læringssituasjoner PedTek.*

Fjuk, A., Dirckink-Holmfeld L. (1995): *Articulation of Actions in Distributed Collaborative Learning.*

Fjuk A., Smørdal O. (1995): *The Computer's Incorporated Role in Work.*

Fjuk A., Korsgaard Sorensen E. (1995): *Drama as a metaphor for Design of Situated, Collaborative Distributed Learning.*

Fjuk A., Øgrim L. (1997): *Towards trancedent thinking in design of distributed collaborative learning environments.*

Fjuk A., Øgrim L. (1996): *The Dichotomy of Distributed Collaborative Learning – Approached through Dialectic Analysis.*

Fjuk, A. (1995): «Towards an Analytical Framework for CSCdistanceL», i Schnase, J. L.; Cunnius, E. L (Eds): *Proceedings of CSCL'95. Computer Support for Collaborative Learning*, Lawrence Erlbaum Associates, NJ, p. 130-134.

Fjuk, A.; Øgrim, L. (1997a): *The tension between tradition and transcendence in designing collaborative learning over distances,* ICDE´97: International Council for Distance Education, The 18th World Conference.

Fjuk, A. (1998): *Computer support for distributed collaborative learning : exploring a complex problem area*, Department of Informatics, Oslo, University of Oslo.

Fritze Y. (2003): *Simulering som strategi-om nærværets kommunikasjon i videobaserte forelesninger*. (Simulation as strategy-about the communication of presens in video-based lecturing)

Føllesdal, D., J. Elster and L. Walløe (1996): *Argumentasjonsteori, språk og vitenskapsfilosofi*, Oslo, Universitetsforl.

Gass, R. (1996): *The goals, architecture and means of lifelong learning : European year of lifelong learning 1996*, Luxembourg, Office for Official Publications of the European Communities.

Greenbaum, J. (1990): «The head and the Heart: Using gender analysis to study the social construction of computer systems», *Computers& Society*, Vol. 20, No. 2.

Greenbaum, J., Kyng, M. (1991): «Introduction : situated design», i Greenbaum, J., Kyng, M.: *Design at work : cooperative design of computer systems*, Hillsdale, N.J., Lawrence Erlbaum.

Gulbrandsen, T. (1995): *Etterutdanning av ansatte i private bedrifter*, Rapport 95/16, Oslo, Institutt for samfunnsforskning.

Handal, G., O. B. Thomsen and L.-G. Holmström, Eds. (1973): *Universitetsundervisning : problem, empiri, teori*, Lund, Studentlitteratur.

Harasim, L. (1989): «Online education : a new domain», i Mason, R., Kaye, A.: *Mindweave : communication, computers and distance education*, Oxford, Pergamon Press**:** pp. 50-62.

Harasim, L. M., Ed. (1990): *Online education : perspectives on a new environment*, New York, Praeger.

Harasim, L. M., et al. (1995): *Learning networks : a field guide to teaching and learning online*, Cambridge, Mass., The MIT Press.

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

Heap, N., et al., Ed. (1995): *Information technology and society : a reader*, London, Sage.

Heap, N., et al. (1995): *Information Technology and Society*, The Open University. Sage.

Hellevik, O. (2003): «Kvantitativ analyse», *Sosiologisk tidsskrift* 11(1): 54-74.

Hellevik O. (1992): *Samfunnsvitenskaplig forskningsmetode.*

Hetland, P. (1995): *Det gjenskapte klasserom : utforming av teknologi for fjernundervisning : evaluering av fjernundervisning via Teleprof C200*, Rapport 95:1. Elverum, Høgskolen i Hedmark.

Holmberg, B. (1993): «Key issues in distance education : an academic viewpoint», i Harry, K., M. John and D. Keegan: *Distance education : new perspectives*, London, Routledge: pp. 330-341.

Holmberg, B. (1995): *Theory and practice of distance education*, London, Routledge.

Holmberg, B. (1990): «A Paradigm Shift in Distance Education? Mythology in the making», *ICDE – International Council for Distance Education. Bulletin*, vol. 22. January.

ICDE june 2-6 1997 The new learning Envionment, A global perspective, Conference Abstracts.

Illeris, K. (1974): *Problemorientering og deltagerstyring : oplæg til en alternativ didaktikk*, [København], Munksgaard.

Illeris, K. (1981): *Modkvalificeringens pædagogik*, Unge Pædagoger, Denmark.

Jonassen, D. H., Ed. (1996): *Handbook of research for educational communications and technology : a project of the Association for Educational Communications and Technology,* New York, Macmillan Library Reference USA.

Jorde, D. (2003): *The role of Information Technology in Teaching and Learning Science*, Gyldendal Akademisk, Oslo.

Jørgensen M. (2002): *A Review of Studies on Expert Estimation of Software development Effort.*

Kaasbøll, J. J. (1998): «Teaching critical thinking and problem defining skills», *Education and Information Technologies*, 3(2): pp. 101-117.

Kaasbøll, J. J., K. Braa and T. Bratteteig (1992): *User problems concerning functional integration in thirteen organizations,* FIRE report 92:8, Oslo, Universitetet.

Kaptelinin, V. (1996): «Computer-mediated activity : functional organs in social and developmental contexts», i Nardi, B. A.: *Context and consciousness : activity theory and human-computer interaction,* Cambridge, Mass., MIT Press**:** pp. 45-68.

Kaur, A: (2001): *Design and Evaluation of a Web-based Constructivist Learning Environment for Primary School Students,* University of Malaysia.

Kirke- utdannings- og forskningsdepartementet/NFF (1996): *Livslang læring og informasjonsteknologi i et europeisk og norsk perspektiv.*

Kirke- utdannings- og forskningsdepartementet (1997): *Ny kompetanse : grunnlaget for en helhetlig etter- og videreutdanningspolitikk,* (NOU 1997:25) Oslo.

Kjellgren, K., et al., Ed. (1993): *Problembaserad inlärning : erfarenheter från Hälsouniversitetet*, Lund, Studentlitteratur.

Knudsen J. C. (2003): *Video mediated communication (VMC).*

Konkurranse, kompetanse og miljø. Næringspolitiske hovedstrategier, NOU 1996:23.

Koschmann, T., Ed. (1996): «CSCL : theory and practice of an emerging paradigm», i Mahwah, N.: *Computers, cognition, and work*, J. Lawrence Erlbaum Associates.

Kuhn, T. S. (1962): *The structure of scientific revolutions*, Chicago, University of Chicago Press.

Larsen, K. A. and J. Eriksen (1994): *Behovet for kompetanseutvikling i staten,* Econ-rapport 1994:104. Oslo, ECON Senter for økonomisk analyse.

Larsen, K. A. e. a. (1997): *Bedriften som lærested : en gjennomgang av etter- og videreutdanning i norske bedrifter*, FAFO-rapport 1997:212. Oslo, Fafo.

Mankiw, N. G., D. Romer and D. N. Weil (1992): «A Contribution to the Empirics of Economic Growth», *The Quarterly Journal of Economics,* 107(2): pp. 407-437.

Mjøset, L. (1991): *Kontroverser i norsk sosiologi,* Oslo, Universitetsforl.

Mjøset, L. (2003): «Sju teser om positivismekritikkens utfordringer ved århundreskiftet», *Sosiologisk tidsskrift* 11(1): pp. 23-44.

Morgan, G. (1986): *Images of organization,* Beverly Hills, Calif., Sage.

Nardi, B. A. (1996): «Context and Consciousness», i *Activity Theory and Human-Computer Interaction,* The MIT Press, Cambridge, pp. 147-174.

Nordisk ministerråd (1995): *Gulltavlene i gresset : livslang læring for alle,* Nordisk ministerråd.

Nordisk Ministerråd (1996): *Handlingsplan 1997-2000*, Nordisk Folkeopplysning og voksenopplæring, Kbh.

Nordkvelle Y. (2001): *Om didaktikk i fleksibel undervisning: konferanserapport,* Didaktikk og teknologi, 7-8 februar. Lillehammer.

Nurminen, M. I., (1997): «Paradigms for sale: Information systems in the process of radical change», *Scanidinavian Journal of Information Systems*, 9(1):25-42.

Ny kompetanse, NOU 1997:25.

Næss, A. and P. I. Haukeland (1998): *Livsfilosofi : et personlig bidrag om følelser og fornuft,* Oslo, Universitetsforl.

Paulsen, M. F. (2000): *Online education : an international analysis of Web-based education and strategic recommendations for decision makers*, Bekkestua, NKI-forl.

Paulsen, M. F. and D. Keegan (2002): *European experiences with learning management systems.*

Perleman, L. J. (1992): *School`s Out. A radical new formula for the Revitalization of Americas Educational System,* Avon Books, New York.

Piaget, J. (1950): *The psychology of intelligence*, London, Routledge & Kegan Paul.

Popper, K. R. (1959): *The logic of scientific discovery*, London, Hutchinson.

Rekkedal, T. and T. Carlsen (1998): *Fjernundervisning og kompetanseutvikling i mellomstore bedrifter : kartlegging av kunnskaper om og holdninger til fjernundervisning,* Bekkestua, NKI fjernundervisningen.

Rekkedal, T. and E. Møystad (1999): *Recruitment barriers to learning on the Internet : survey among active correspondence students and prospective students at NKI*, Bekkestua, NKI fjernundervisningen.

Salomon, G., Ed. (1993): *Distributed cognitions : psychological and educational considerations. Learning in doing,* Cambridge, Cambridge University Press.

Statssekretærutvalget for IT and T. Rudihagen (1996): *Den norske IT-veien : bit for bit : rapport fra Statssekretærutvalget for IT,* Oslo, Samferdselsdepartementet : Akademika : Statens trykksaksekspedisjon.

Studietur - Australia - 19. januar-4. februar 1996 : rapport, Lillehammer, Høgskolen i Lillehammer.

Svoen, B. (1995): *Dataspill som undervisningsmetode : om multimedieteknologi som verktøy i opplæring*, Oslo, Universitetet i Oslo.

Veer, R. v. d. and L. S. Vygotskij, Eds. (1994): *The Vygotsky reader*, Oxford, Blackwell.

Verdejo, M. F. and S. A. Cerri, Eds. (1994): *Collaborative dialogue technologies in distance learning*, NATO ASI series. Series F, Computer and systems sciences. Berlin, Springer.

Vygotskij, L. S. (1962): *Thought and language*, Cambridge, Mass., M.I.T Press.

Vygotskij, L. S. (1978): *Mind in society : the development of higher psychological processes*, Cambridge, Mass., Harvard University Press.

Wells, R. A. (1990): *Distributed Training for the Reserved Component:Remote Delivery Using Asynchronous Computer Conferencing*, Report 2Q263743A794, Idaho National Engeneering Laboratory. Idaho Falls, ID.

Wells, R. (1993): «The use of computer-mediated communication in distance education: progress, problems and trends», i Davies, G.; Samways, B. (Eds.): *Teleteaching. Proceedings of the IFIP TC3 Third Teleteaching Conference*.

Øgrim, L. (1993): *Ledelse av systemutviklingsprosjekter : en dialektisk tilnærming*, Institutt for informatikk. Oslo, Universitetet i Oslo.