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Evaluation of Learning Processes in general and Computer Supported Learning Processes in particular

Experiences from experiments with Computer-Supported-Flexible Learning Processes

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Summary:
The present paper is focusing on evaluation of learning processes with emphasis on challenges with computer supported learning. Developers in the field are concerned improving learning processes, but the approaches suffer from precise definitions of the term quality. A more conscious approach to the definition of what constitutes high and low quality of learning processes is required.

The discussions in this paper are based on experimentation in the PedTek (Pedagogy and Technology) project involving experimental development of computer supported learning systems for off-campus college students during the past six years. Approaches and methodology applied for successful evaluation of the learning processes in PedTek is presented in this paper. For evaluation of computer supported learning processes for off-campus students it is suggested that the four phenomena; Learning outcome, Flexibility, Resource requirements and Learners satisfaction are used as success criteria. Experience from the experimentation indicates that evaluators of learning processes must apply both positivistic inspired methodology and use intuition for determining the quality of learning processes. Variables and phenomena must be identified and operationalized. But the evaluators must also take the risk of being less unscientific by going beyond established methodology. Reluctance against approaching evaluation of learning process in new ways is explained by the researcher's fear of either be characterized as unscientific or as positivists by adapting methodology from the natural sciences in the domains of social sciences.

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Tittel: Evaluering av læringsprosesser generelt og IKT støttede læringsprosesser spesielt			
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Sammendrag:
Denne artikkelen fokuserer på evaluering av læringsprosesser med vekt på utfordringer knyttet til IKT støttet læring. Utviklere på dette fagområdet er opptatt av forbedring av læringsprosesser, men tilnærmingene lider ofte av upresise definisjoner av kvalitetsbegrepet. En mer presis definisjon av hva som menes med høy og lav kvalitet på læringsprosesser er nødvendig.

Diskusjonene i denne artikkelen er basert på eksperimenteringer utført i PedTek (Pedagogikk og Teknologi) prosjektet som har involvert utvikling av IKT støttet læringsløsninger for fjernstudenter i løpet av de siste seks årene. Tilnærminger og metoder for suksessfull evaluering av læringsprosesser i PedTek er presentert i denne artikkelen. For evaluering av IKT støttede læringsprosesser er det foreslått at de fire faktorene; Læringsutbytte, Fleksibilitet, Ressursbruk og Student tilfredshet benyttes som suksess kriteria. Erfaringer fra eksperimenteringen indikerer at evaluering av læringsprosesser både må anvende positivistisk inspirerte metoder og intuisjon for å bestemme kvaliteten på læringsprosesser. Variabler og fenomen må identifiseres og operasjonaliseres, men evaluering må også ta sjansen på å være uvitenskaplige ved å overskride etablerte metoder. Motstand mot ny tilnærming til evaluering av læringsprosesser kan forklares med mange forskeres bekymring for å enten bli karakterisert som uvitenskaplige eller som positivister ved å anvende naturvitenskaplige metoder på samfunnsvitenskaplige områder.

Introduction

Researchers and developers in the field of education are concerned with understanding and developing new and improved learning processes, but many approaches are suffering from an unsatisfactorily clarification of what constitutes good and bad solutions. If progress in the field of developing new and improved learning process shall be enhanced, a more conscious approach to the definition of what constitutes high quality learning processes must be adapted. Developing and testing any process, system or product requires a definition of what constitutes successful solutions. Absence of such definitions leaves the developers with little or no means for maneuvering. It becomes impossible to evaluate the experiments and consequently, the developers are without the possibility of drawing conclusions and suggesting improvements. The more accurate the phenomena, quality, is defined and operationalized the better is the maneuverability and the more efficient and focused the development process can be conducted. The success of development projects is hence determined by the degree to which pre defined goals are reached. Conducting experiments requires that success criteria are defined and converted to operationalized variables and phenomena, qualitatively or quantitatively measurable. But simultaneously, evaluation must also go beyond what is considered established scientific methodology and to some extend apply intuition based approaches and the balance between these approaches represents a considerably challenge.

The PedTek project

The research findings presented in this paper are based on analysis and interpretation of empirical data collected during the experiments in the PedTek (Pedagogy and Technology) project. PedTek was initiated in 1997 and the Norwegian Ministry of Education and Research granted 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. The experimentation process of PedTek was terminated in fall 2002. Throughout a period of six years experiments were conducted based on principles from experimental systems development and the development objective 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.»

A four-component Net Based Learning Environment (NBLE) prototype was, developed, tested and continually redesigned during the experimentation. Based on constructivist learning theory and in particular the work of Piaget and Vygotsky, operational NBLE prototypes were 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» information from a surrounding support system and allowing the construction of new knowledge. Traditionally, formal learning processes have 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)

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. Approximately 650 undergraduate Computer Science students have attended the experimental courses during the project period. 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, exposed to the prototypes during the PedTek experimentation. Experience from this traditionally organized course allowed for valuable comparison 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.

Evaluation methodology and approach

With the increasing application of computer supported learning processes the research and development community has paid a correspondingly increased attention to the quality of learning processes and evaluation. When proposing educational solutions, deviating considerably from what is rooted in long traditions among educators, the need for justification is more pertinent. With the experimentation conducted in the PedTek projects this has been a motive.

> «There are many motivations for conducting an evaluation: it may be a required component of the funding source; it may be an institutional request; it may be the interest of enthusiasm of the proponents and participants.»
> «The field of educational evaluation has developed very rapidly over the same period that computer conferencing has been used in educational settings. The «state of the art» of educational evaluation has recently been described as: … a multidimensional, pluralistic, situational, and political activity that encompasses much more than simple application of the skills of the empirical scientist.» (Mason R. 1991)

In the Najaden Papers, a conference on Evaluation Methodologies for Computer Conferencing Applications in 1991, it is claimed that three alternative paradigms have emerged from the evaluation debates of the last 20 years:

> «Postpositivism: an experimental, quantitative core buttressed by critique from varied analysis, theoretical perspectives, and value frameworks, combining the use of

> survey and observational data, with regression and cluster analyses.
> Interpretivism: based on the social constructions of meaning being inherently time and place dependent; therefore, relies heavily on qualitative methods, especially interviews and observations, and acknowledges and legitimates the value-laden nature of inquiry.
> Critical theory: seeks to illuminate the historical, structural and value bases of social phenomena and to catalyse political and social change – not through paricular methods, but through awareness of one's situationally-located standpoint.»

The PedTek approach represents a combination of parts from all three paradigms and the data retrieval 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 in the PedTek project. The fifth category, intuition, is included to cater for and justify conclusions, which goes beyond formal methodology. 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 were conducted with students, administrative staff 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 were frequently overlapping with participant observations. During and at the end of each concluded learning process the students were asked to complete a questionnaire. This was in most cases presented to the students during a mandatory gathering, thus ensuring

a high percentage of feedback from the students involved in the experimentation. A questionnaire was also send 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 includes the information gained from cooperating with the students on campus, either in direct connection with the experimental courses, or in the discussions of other issues. From a researchers point of view, the opportunity to «mix» with the research objects, the students, in natural ways is a great advantage.

Some uncertainties are involved with respect to the validity of the data collected, due to what is commonly denoted as the «Hawthorne effect». This term originates from experience gained by the Human Relation school in the nineteen fifties and sixties when experiments where carried out in the workplace with the purpose of understanding and improving work environments in factories in the UK. These experiments indicated that attention from the researchers in it self had positive effects on the workers 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 experiments. However, it is difficult to conclude to what extend 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 members of faculty.

As opposed to traditional lectures, computer supported learning processes frequently provides automatic registration of what goes on among the learners and the learners and supervisors. With technology mediated communication, applying web-based Learning Management

Systems (LMS), the temptation to draw conclusions, based on what is registered electronically, is high. During the experimental process of PedTek this option was considered but rejected as it became apparent that monitoring the electronically activity only provided part of the story of the past activities.

> «Most conferencing systems provide automated user statistics, or else these can be compiled by systems operators relatively inexpensively …. This information gives a useful framework for any evaluation, but as the only data for evaluation, it is not only inadequate, but actually misleading. As critical theory has established, the methodological choices evaluators make are never value-free.» (Mason R. 1991)

With heavily technology mediated interaction between peers and peers and experts, the attention of the researchers and developers is inevitably drawn towards how the technology function as a communication and interaction mediating media. The focus can then easily be shifted in the direction of the technology mediated activity at the cost of reducing the attention to other, equally important activities.

> «A researcher must attempt to isolate the effects of a communications medium from the interrelated effects of such things as group dynamics, personal attitudes, and topical content of the communication. In a situation such as this, there is the constant danger of simplifying the «real world» to meet the limitations of the laboratory.» (Mason R. 1991)

Success criteria

The R&D process conducted in PedTek is represented by two sub processes. The first is the development process and the second is the

research process consisting of both a feedback oriented part and an explorative part.

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

With the above 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

Success phenomena and quality of NBLE solutions

When the students attending a course are experiencing a high learning outcome, have a highly flexible learning situation, 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 ordinary

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 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 for determining the success of prototypes tested during experimental development processes, the phenomena must be operationalized and represented by measurable variables.

Learning outcome

The phenomena, «Learning outcome» refers to the knowledge enhancement of the students attending a particular course or learning process, and is related 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, an, 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 enhancement of the students' ability to work independently and take responsibility for own learning. However, the definition of the phenomena, learning outcome used in PedTek is controversial since it does not include other equally important effects of being a student, such as skills in socialization, tolerance etc. The exclusion of these effects 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 striving to improve 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)

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 enhancement of higher order thinking skills 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 post learning process tests of the students are required.

Measuring Learning outcome

Operationalization of the phenomena, «Learning outcome», requires definitions and understanding of what is meant by «knowledge according to a predefined curriculum» and «other formal learning goals». Applying the phenomena, as a success criterion requires further that the phenomena can be represented by quantitatively or qualitatively measurable variables.

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 «portfolio».
- 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 student's ability to work both 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 the PedTek projects, 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 was paid to their knowledge and skills related to project work. In particular, their performance related to how they conduct their final year project 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 which may effect the enhancement of knowledge and skills among the students.

Flexibility

The phenomena «Flexibility of 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 most off-campus

students, engaged in learning programs, as part of a life long learning processes where they are combining studying with jobs and family obligations.

Measuring Flexibility

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, operationalization of the phenomena will be 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 included, which compare the present situation and present requirements with the situation in a traditionally, lecture based learning process. This additional definition, can to some extend be measured and represented by variables based on quantitative empirical data.

Resource requirements

The phenomena «Resource requirements» refers what is required of resources, both by the students and the educational institution, for delivering a particular course using NBLEs. For most practical applications, a measure of the performance of a learning environment has little meaning without considering the amount of resources required. 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.

Measuring Resource requirements

Based on the above definition the phenomena «Resource requirements» is objectively 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 variable groups, the «values» relative to what would be the situation with traditional lecture based learning processes is of major importance. Most learning process require some resources for all these variable 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, requiring the use of high tech. solutions, the hidden factors may be extensively present in the form of frustrations and inter colleagues learning. Time spent by members of the organization, 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.

Learner's satisfaction

The phenomenon «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 can 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 phenomenon 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 institution will not, in the long run, be competitive in the student's marked. In this sense the phenomena «Learner's satisfaction» is both a means and a goal.

Measuring Learner's satisfaction

Determining the degree of learners' satisfaction is almost entirely a question of registering students' attitude. The challenges with respect to this 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 clearly indicates that the students' opinions about the learning process changes considerably during the term. With untraditional pedagogy such as PBL and CL, the levels of frustration are often high at the early stages of the learning process. But, when the learning process is terminated, and the majority of the students realizes 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.

Conclusions

A significant result from the PedTek project is that evaluators of learning processes must dare to adapt more positivistic inspired methodology combined with intuition when evaluating the quality. Measurable variables must be identified and operationalized if possible. But simultaneously, the evaluators must also take the risk of being characterized as unscientific by going beyond established methodology. The reluctance against approaching evaluation of learning process in new ways can be explained by the individual researcher's fear of either be characterized as unscientific or as positivists when adapting methodology from the natural sciences in the domains of social sciences. But, neither of these approaches excludes the other. Evaluation of prototypes during the PedTek experimentation was based on a wide specter of methodologies and retrospectively it can be concluded that this was successful. It is particularly worth considering that 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 suitable for written presentations. These experiences, knowledge and skills are embedded in the organization, as organizational learning, represented by a more conscious relationship, among the members of the organization, 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 unconscious learning process, among the faculty and staff at HUC. With computer supported learning, automatic assessments based on transcripts from electronically mediated communication are frequently

attempted. This information gives a useful framework for any evaluation, but as the only data for evaluation, it is not only inadequate, but actually misleading. In a situation such as this, there is the constant danger of simplifying the «real world». A major objection to evaluation based on the success criteria presented in this paper is that they are not sufficiently comprehensive to cater for all the important aspects and effects of education. Restricting focus to the four success criteria, *Learning Outcome*, *Flexibility*, *Resource Requirements and Learners Satisfaction*, represents a considerably simplification. The goals of modern education includes training and learning processes for enhancing socialization, tolerance, solidarity and more which are attitudes and skills required by citizens in most societies. Further development of evaluation methodologies should attempt to include these and other factors as success criteria when evaluating educational programs. However, including these factors do not change the recommendations of evaluation presented in this paper. Whatever phenomena are included as criteria of success it is requires that these, whenever possible, are explicitly defined and operationalized. But when these positivistic inspired approaches are exhausted the researchers must have competence and be willing to apply more intuition based approaches even if this implies going beyond established methodology.

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