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Project-organized collaborative learning in distance engineering education

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Abstract: Transferring a successful on-campus project-organized learning method to distance continued education is complicated by the fact, that the target group as well as the learning environment and forms of communication are fundamentally different. The Master of Industrial Information Technology distance education has been selected for experiments with utilization of new information and communication technology and didactic adjustments to make this transfer from on-campus to off-campus a successful endeavor. The adjustments, as well as the assessment of their effect, are based on a systematic monitoring and evaluation of the first year, and subsequent reflections by students and teachers.

Introduction (n2)

Project-organized problem-based collaborative learning has been a successful learning method at Aalborg University (AAU) since its start in 1974. For engineering educations this is documented by a number of evaluations (Fink 1999, Kjærsdam and Enemark 1994, Kolmos 1996). The merits of this 'Aalborg Model' are increased motivation, excellent development of analytical skills, experience in coping with real-life problems, and extensive peer collaboration. Because the project organized form supports the learner's active exploration and selection of what is most important to learn, it is an excellent regulator of the learning process. In recent years continuing education programs based on technology-supported distance education have been developed at AAU (Bygholm, Hejlesen and Nøhr 1998, Jensen et al 2003, Lorentsen 2000), and distributed collaborative learning has been an object for research (Dirckinck-Holmfeld and Fibiger 2002, Fjuk and Sorensen 1997). It has therefore been natural to use the Aalborg model as a basis for distance education as well. With the Master of Industrial Information Technology (MII) distance education (Knudsen et al 2000, Masteruddannelse 2002) as an example, this article describes how positive experience with the Aalborg model in on-campus engineering programs was attempted transferred to an off-campus program.

The merit of distance education is to provide educational opportunities to individuals at times and places of their convenience. Traditionally, distance education has been characterized by one-way communication and self-study, whereas on-campus project-organized learning is based on dialogue and collaboration. This apparent conflict suggests that the Aalborg model cannot be directly transferred to distance education.

The target group is another difference. The typical MII students differ from the regular MScEE students as they already hold a bachelor degree or equivalent and have a full-time job and a family. In addition they constitute an inhomogeneous group of people regarding age, former education and professional career.

Consequently, to obtain a successful implementation of project-organized collaborative learning in distance education, two measures have been taken

- Extensive utilization of new information and communication technology (ICT)
- Didactic adjustments of the Aalborg model

The basis year of the MII education was monitored during its first three years of existence (1999-2002). The students' evaluation has been recorded and measured by questionnaires and other surveys, and the results, combined with the teachers evaluation and reflection, have given grounds for adjustments of the ICT-tools and, in particular, of the didactics.

This paper describes a transformation of the Aalborg model from on-campus to off-campus engineering programs – what works well directly, and what requires adjustments for being transferred to mediated education.

Method (n2)

In the spirit of engineering research the MII education program has been considered an experiment, as specific impacts and changes were made, and the corresponding effects were monitored and evaluated. À priori we had

- The Aalborg-model for on-campus engineering education programs: project work in groups takes up half the study time, and the remaining time is used on courses
- Others experiences with distance education, from literature (e.g. Bygholm and Dirckinck-Holmfeld 1997), conferences, workshops and personal contacts
- Personal experiences with developing new education programs: most of the MII staff have been active in developing and implementing the Aalborg model on campus
- A common basic learning theory: social-constructivist learning principles are combined with Cowan's reflection loops (Cowan 1998, see below)

The experiment was designed on this basis. It consisted of a full-scale experiment comprised by the MII basis year, and small-scale laboratory experiments in e-learning lab (www.ell.auc.dk), testing the technological potentialities.
The experiments were then conducted and followed by

- Systematic evaluation: results data are collected by questionnaires, interview surveys, plenum and personal discussions, and student process reports.
- Analysis and reflection: Cowan's model is applied by the staff as well as the students.
- Revision: didactic improvements are implemented after each year. New technology is put to use and the application of ICT is improved.

The revision constitutes a new experiment, and the circle is repeated, which is paraphrased by Cowan as taking another loop.

Learning theory (n3)

The program is based on social-constructivist learning principles, combined with Cowan's 'reflection loops' (Cowan 1998), as it is commonly recognized that reflection has a predominant place in problem-oriented group-based learning. Cowan has combined Kolb's 'learning cycles' (Kolb 1984) and Schön's ideas about reflection in learning processes to a concept based on three planned reflection loops for, in (the middle of), and on (after) the learning process. Each loop corresponds to one of Kolb's ´learning cycles`, where students in a group together shall reflect on their experiences to generalize rules and plans for their team work and project management, to be carried out in the coming project period. The so-called modified Cowan diagram is illustrated in Figure 1

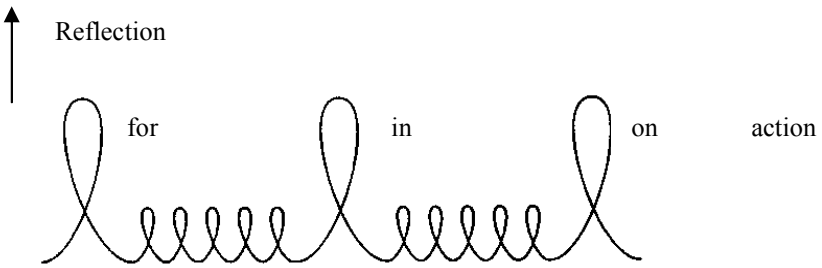

Figure 1. Modified Cowan diagram with three planned reflection loops

In the MII program, these major reflections are facilitated by the teachers and set to take place in three specific seminars. The main purpose is to enhance the quality, depth and relevance of what is learned, both according to the projects and about distance team work. In addition, reflection should take place in other seminars and at virtual group meetings. These small, unplanned reflection loops are supposed to level out differences in knowledge between the individual group members, which is greatly needed in distance education.
For the MII teachers the theory has been useful in their three functions: lecturer using exercises to provoke reflections on major issues in the course, project supervisor asking reflective questions in stead of giving answers and learning about the students learning process, and, in particular, developer of the education program where both the students reflections and reflections among the teachers are used to improve and adjust the MII program every year.

The on-campus and off-campus programs (n2)

In both programs, on- and off-campus, project work in groups is the primary element. The project work is intended to take up half the study time, while the remaining half is devoted to courses. There are two types of courses, general study related courses with exams, and project related courses examined via the project.

On-campus implementation of engineering programs (n3)

The students groups, typically consisting of 5-6 students, have their own group room, which is their base every day from 8 a.m. to 4 p.m. They go to lectures together, do course assignments together in the group room, work on the project – often in sub-groups, and take most breaks together. This engenders and allows a great deal of informal communication of relevance to the studies, easy opportunity for help with various minor problems, and strong social contact.
The courses consist of 4-hour sessions, a lecture followed by assignment work, where the teacher goes to the group rooms to discuss and help out with the assignments. In project work, the group has an assigned supervisor, with whom they have a weekly meeting, based on written preparatory material from the group. In addition, the students have easy access to supervisor and teachers whenever there is a problem, that can't be solved in the group.

The MII program and its off-campus implementation (n3)

The Master of Information Technology education, MII (Masteruddannelse 2002) is a 3-year program, corresponding to 90 ECTS (European Credit Transfer System units) with an expected study load of 20 hours per week. It consists of a 1-year general basis program combined with one of five different 2-year specialisations.
A small first project (called pilot project) focuses mainly on training project work in groups in a learning situation where an important part of the communication is mediated via the Internet. This is supported by a course in 'Technology based collaboration', where Cowan's three planned reflection loops plays an important role in planning (facilitated reflections at seminars) and testing (distance project work between seminars) how the group works. The reflection on action is documented in a process analysis, which is discussed at the evaluation of the pilot project. Consequently it is also serving as a reflection on action for the subsequent main project. This can, for example, deal with analysis, design and implementation of a system for

processing production data from a database via an Internet browser. During the project period there will be reflection in and on the actions just as in the pilot project.
The program is organized as a technology-based distance education framed by seven two-day seminars per year. A special web-based distance education system, Uniflex, has been developed to support courses as well as project work (Borch et. al. 2003). Amongst other things, Uniflex makes the courses available in a standard form, comprising introduction, course description, technical content, references, self test, problems with hints, and course evaluation. Each course unit has a built-in newsgroup for discussions, questions and answers.
The seminars take place at Aalborg University from Thursday afternoon to Saturday afternoon. The face-to-face contact with project group members and with supervisors is used intensively for the parts of the project work, which is difficult to handle electronically, general discussion and planning in particular. New courses are also introduced, typically with a lecture and problem solving assignments to match. Courses are reviewed with question and discussion sessions and elaborated through further lectures. In addition, there are guest lectures, study course exams, project exams, and evaluations and discussions about the program.
Project work between seminars is based on weekly synchronous virtual meetings with audio, text and recently video, as students and supervisors have as a basic requirement home computers with Internet connection, microphone headsets and web cams. The supervisor follows these meetings, which last one to two hours. Most groups have chosen to use Yahoo Messenger. In addition to these synchronous meetings, there is continual asynchronous communication via e-mail and through Uniflex where documents are uploaded and reviewed.

Results

The systematic evaluation includes a variety of methods, interview survey, questionnaires, plenum meetings, process reports, and informal observations and discussions by students and supervisors. The results most relevant for this paper have been selected and presented in the following.

Qualitative interview survey
The qualitative interview survey was conducted the third year by telephone, 1½ month after the start of the basic year, and had the participation of 16 out of 17 students (Semey 2001). The motive for this early investigation was to obtain the students immediate reaction to the new study form in relation to their expectations.
The purpose of the survey was to

- evaluate the collaboration in the project group
- investigate the interaction between technology and communication within the group.

The main responses focused on:
Start up problems: Fast reaction and solution to technical problems was appreciated. There had been some confusion because of information overload about the program.
Project and group work: A high learning efficiency was expected. When the interview was conducted, some of the students were not pleased with the initial focus on the learning process in relation to project work – they believed they learn better from courses than from project and group work.
Synchronous chat meetings: Initially a slow and disordered way of communication, but most groups had already learned to structure their meetings with agenda, roles and rules. While face-to-face was felt to be the ideal form of communication, some advantages of the combined verbal and written communication of virtual chat meetings were mentioned.
Asynchronous communication: The course newsgroups were not used much. Mail, document exchange via Uniflex and telephone were used within the project groups as supplement to the chat meetings.

Questionnaire
Each year (2000, 2001 and 2002), within a week after completion of the exam, MII students have been asked to complete an evaluation questionnaire containing approximately 60 ques-

tions in 7 categories: Pilot project, main project, group work, courses, general about curriculum, technology and software tools, organization and private/family life.
Any modification and/or addition of questions from year to year have been made with attention to keeping a valid basis for comparison between the three years. The response rate in 2000 was 10 out of 14 students, in 2001, 9 out of 13 students, and in 2002, 8 out of 8 students. The questions most relevant for the issues in this paper are listed below in Table I.
The answers for each question are given either as representative answers in condensed form, e.g. 'yes', direct quotes in " ", or e.g. 'yes/no = 3/6' meaning 3 answered yes and 6 answered no.

	Question	Responses 2000	Responses 2001	Responses 2002
	Pilot project			
Q1	Do you feel that the pilot project was beneficial to the main project?	Yes	Yes	Yes/no: 4/2
Q2	Do you have recommendations for alteration in the pilot project?	No	More control	Yes/no: 3/2. More technology, include Java and OO*
Q3	Mention some positive experiences you had during the pilot project.	Group collaboration	Virtual collaboration	Group collaboration
Q4	Mention some negative experiences you had during the pilot project.	Technology (Luvit, www.luvit.com).	Uncertainty	Limited learning of technical subjects
	Main project			
Q5	Was the project suitable for distance education?	Yes	Yes	Yes/too complex: 2/4
Q6	2001: Was there sufficient time for both courses and project work? 2002: Is it too difficult to work on several courses and the project simultaneously?		No, some of the courses were given too little attention	Yes, it was too difficult: 6
Q7	What is your opinion of the Aalborg model applied for distance education?	Good but difficult	Good but difficult "Too much energy is spent on less relevant activities, a tighter control is necessary".	Good/Adjustments required: 2/3 "The danger is that the courses are given a lower priority at home […], because in the project you have some deadlines as agreed with your fellow group members."
Q8	What is the hardest part of distant project work? Name examples.	Slow communication	Discipline, motivation	Communication. "The physical distance was a problem we learned to overcome".
	Group work			
Q9	What was your experience of the group work?	Difficult, slow communication	Surprisingly good	"Fine". "Difficult due to lack of simultaneousness". "A fiasco as 2 group members dropped out". "A positive experience".
Q10	Do you have recommendations for improvements of the communication?	Sound is missing	Better technology	Full duplex
Q11	How were the interaction and the collaboration with the other members of the group?	Good	Mostly good	OK
	Courses			
Q12	Have you used knowledge from all courses in the project.	Yes	Yes	Yes/no: 3/1
Q13	Was the communication with teachers satisfactory	Yes/no: 3/5	OK/not utilized: 6/2	OK/not utilized: 2/3
Q14	Did you utilize the possibilities for discussing the course material with fellow students	Yes/no: 5/4	Some/no: 6/3	Some/no: 5/1
Q15	What do you miss most com-	"Fast response	Fast response	Direct contact with teachers and fel-

	pared to ordinary class	from teachers"	"A kick in the …"	low students
	Technology			
Q16	Have you had technical problems	Yes, with Luvit in particular	Some	No
Q17	How often did you use Uniflex		Several times per week	From weekly to 5-10 times per week. Mostly for courses
Q18	Do you find Uniflex well suited for courses		Yes. Problems reading from the screen	Yes
Q19	Do you find Uniflex well suited for project work		Yes/no/some: 2/1/7	Yes/no: 3/2. Better version system and better overview to be desired
	General/Reflection			
Q20	Your general opinion about the basic year in relation to your expectations	OK. Too difficult and too high a workload	Generally good	Good. The workload too high.
Q21	How did you find the mixing of distance learning and on-site seminars?	The seminars can be utilized better (more courses)	The seminars gave valuable 'kicks'	Good. "Too little communication on distance, but that is our own fault".
Q22	Was it possible to combine work and education in this form	Yes/no/difficult: 4/3/4	Yes but hard	Yes (4). Too high cost for the family (1).
Q23	What did you experience as the primary benefit of net-based distance education			Possible to combine with a full-time job. Less time needed for transportation. "Easy to fit into everyday life". "Can take the education I want at a distant university".
Q24	What did you experience as the primary disadvantage of net-based distance education			Missing direct contact with teachers and fellow students. Missing face-to-face: communication difficult, more time consuming.

Table 1: Questions and responses from basis years 2000, 2001 and 2002.

Plenum meetings

At the conclusion of each on-campus seminar, the content of the seminar and the general study situation was discussed and reflected upon in plenum. In particular, an unofficial project course exam seminar in Feb. 2002 became an impromptu evaluative meeting. Many constructive and useful points were noted.

The students stated that:

- as the project was a collaborative assignment, the group members felt a heavier responsibility towards the project than towards the courses and their own learning in general,
- they spent more time on the project than the courses (up to 80%),
- they were behind with the project courses, so the technical level in the group varied a great deal and was generally too low,
- due to lack of technical insight required for the project, the project work took too long, which in turn decreased the time available for course studying - a vicious circle!

The students also gave recommendations for adjustments to acquire a better balance between course and project work. They are as follows:

- Give project work a lower priority in certain periods.
- Work on course content in groups (transfer some of the feeling of group-responsibility from project to courses).
- Compulsory course assignments by each group.
- More course evaluation exams.

Process analysis and supervisor observations

In each project report, the pilot project in particular, the students analyse the learning process and the collaboration in a specific process analysis part. This gives rise to reflections in the group, and discussions and reflection at the project exams. The supervisors combine this ex-

perience with that obtained by the other sources, and the outcome is used in the analysis and adjustments (see next section).

E-Learning Lab experiment in virtual collaboration
The third year, the following experiment was conducted in the e-Learning Lab at Aalborg University (www.ell.auc.dk): each group solved a problem in collaboration, as the students were placed at separate PC's placed in the same room but not facing each other . Yahoo Messenger and NetMeeting were used simultaneously for communication, allowing text, audio, video, whiteboard and document exchange. The problem, related to a course in Java programming, were: *Make a system, where you can enter a text string in a browser, and pressing a button displays the string reversed.* Each student was given a separate part of the problem/solution on paper and Java or html code on his PC. Together the group should design the system, put the pieces of code together and test the system. For practical reasons there was a time limit of 45 minutes.
After conclusion of the experiment, it was evaluated by a discussion with the three participating groups. For several reasons some of the students did not consider it a realistic replica of a virtual group meeting: The meeting, in particular the distribution of tasks, was not prepared in advance through asynchronous communication. The time limit made it feel more like a test, so two of the groups did dot take the time to elect a chairman. The two simultaneous tools, Yahoo Messenger and NetMeeting, made the user interface confusing. There were, however, several more positive inputs: The whiteboard is a useful device for graphical communication, in particular if a pen is available. The participants could use different colours for easy identification of the sender. Speed and technical quality is very important, e.g. a better sound quality is desired. Consequently, it is obvious that new technology needs to be explored constantly. The importance of good habits in the weekly group meetings with roles and rules was made clear.

Analysis, discussion and adjustments

The results of the previous section are collated, organized in subject areas, analyzed and discussed. Because of the vast amount of data, their different nature – qualitative and quantitative – and different time of obtainment this is a difficult task. It is also impossible to be completely neutral, but we believe that a reasonable true and fair view is presented, and that the didactic adjustments, that are a consequence of of this analysis, are well founded.

The Aalborg model as study form: Many distance students have adapted a result oriented attitude from their work, and as they have limited time for studying, they expect an efficient, strictly planned study program for their money. Although they are accustomed to projects and group collaboration from their work, they are initially sceptical about the use of this method in a learning situation, especially the high focus on the learning process in relation to project work in the pilot project (interview survey 1½ month after start). After having tried the off-campus Aalborg model for a whole year, the findings show a change in that attitude. Now most students state that the pilot project was beneficial to the main project (Q1) and they find their experience with group collaboration positive (Q3). Although some of the students in 2002 find that the main project was too complex, all the others find that it was suitable for distance education (Q6).
A typical statement about the Aalborg model is that it is good but difficult and that adjustments are required (Q7). The opinions about group work in learning are mixed, but several find it surprisingly good (Q9). As the questionnaires are only completed by the students that finished the first year we cannot claim that all students will find the Aalborg model a good way of studying. We know from supervisors observations that although a very common reason for dropping out is lack of time, some students have also stated that they did not feel, that the study form was right for them.
The project is an excellent motivator, which is highly needed in distance education. But because of solidarity with the group they spent too much time on the common project work, and

too little on courses (Q6, Q7 and plenum meeting). As knowledge from all the courses are used in the projects (Q12) the students in 2002 recommend a stricter control, e.g. by compulsory problem solving in courses and project-free periods (expressed at plenum meeting). These findings and suggestions for improvement matches the reflections in the process analysis and the supervisors observations very well.

Communication: face-to-interface communication is experienced as slower and as less subtle than face-to-face (Q8, Q9), and not well suited for brainstorming, planning, and solution of personal problems (process analysis and supervisor observations during planned reflections and at the seminars). However the students learned quickly to utilise the virtual meetings in the project work (interview survey and Q8), realizing that they require more preparation and meeting discipline than face-to-face meetings.
Communication with teacher in relation to courses was limited to approximately half of the students (Q13, Q21) and a similar result was seen the first year in the communication between the students in relation to courses, but here we find a clear improvement in the number of students communicating during the years (Q14). This appears to be a general problem in many distance programs. Ben-Jacob (Ben-Jacob and Levin 1998) has experienced that "the more technical the course is, the more reluctance there has been on the parts of the students to engage in on-line discussions".

Technology: The students all have a strong background in IT, and it is a tool for as well as the content of MII. Consequently they have an interest in applying new tools for electronic communication (Q4, Q10, and the e-learning lab experiment). In particular, a tool integrating synchronous text, audio, video, whiteboard and document exchange is needed. The first year, there were some technical problems – in particular with an inadequate learning environment (LUVIT, manufactured by Luvit A/B, www.luvit.com)(Q4, Q16) – but as our technical service (with Uniflex) and the student's knowledge improved, there were only minor problems the following years (Q16).

General: The students are generally satisfied with the distance education form, appreciating the flexibility. Although they consider their workload very high, they find it possible to combine the education with a job and a family (Q20, Q22, and Q23). It should be noted however, that this is primarily the opinion of the students that did not drop out during the first year (roughly 50%).

Conclusion: Based on the results and the analyses, the following conclusions have been reached. The project groups learned to organize and conduct efficient virtual meetings quite rapidly. It is well known from on-campus education that certain phases of the project can be quite frustrating. Face-to-face communication is without a doubt optimal, but there might be a tendency to ascribe every problem to the difficulties with face-to-interface communication. The synchronous communication can certainly be improved as new and faster technology is available, and as we learn to utilize it better. It is, however, equally important to adjust the didactic to fit the communication at hand, and here the supervisors agree with the students recommendations as expressed at the plenum meeting.
During the 3 years, adjustments of the basis year program have been made. In particular, the relationship between courses and project was strengthened by giving small problems and assignment in the courses, directly applicable in the project. In addition, unofficial course exams were conducted at the seminars, where the assignments were discussed, and the reflections on the relation between the courses and projects were encouraged. As the questionnaire responses and the plenum discussion indicate, all we achieved was an improvement in the number of students communicating about the courses, but this was not sufficient for an optimal balance between course and project work.

Didactic adjustments: After the third year we realized how the strong feeling of group responsibility puts too much emphasis on project work at the expense of coursework. Conse-

quently a more radical adjustment plan was adopted. It includes a project-free period, as the basis year is divided up into three phases:
Phase I: Pilot project and related courses. The primary aim is to learn group-organised project work in web-based distance education, including a familiarisation with relevant collaborative and communicative tools. The secondary aim is to become familiar with the technical content of the project, in this case construction of databases. This phase has only minor changes, and planned and facilitated reflection loops will still be used.
Phase II: A project-free period with courses only. The aim is to obtain knowledge and comprehension of course subjects, (c.f. Blooms cognitive taxonomy).
There shall be compulsory course assignments by groups with strict deadlines and oral examination of these assignments at seminars. An objective is, to enhance student communication and collaboration in courses by transferring some of the feeling of group-responsibility from project to course work.
Phase III: The main project, no courses. The aims are two-fold: application, analysis, synthesis, and evaluation (Bloom) of the technical subjects, in particular interdisciplinary application, and experience with project work in a learning situation in a virtual environment, including documentation in a report also containing the reflection on action as a process analysis.

Conclusion

Three years of experience with the MII basis year indicate that a successful project-based and group-organised learning model for on-campus engineering programs, the Aalborg model, can be transferred to distance education - with some adjustments. This is the conclusion based on a systematic evaluation and feedback from the students.
Cowan's learning principle/model (Figure 1) has been a good help in planning and adjusting the education, using both the students planned reflections and reflections among the teachers. The greatest benefit of the facilitated reflections is, that it enhances the students learning and focus on the fact that their projects and group work is a learning process and not a team solving a complex task for a company as in the students working life.
The main problem areas for this study have been:

1. Communication: Synchronous chat meetings with text, audio and video, and asynchronous document exchange via Uniflex and e-mail constitute the major part of the communication required for project work in groups. However, face-to-face contact at the seminars is a highly appreciated supplement.
2. Study form: The expectation of many continuing students is an efficient and strictly controlled program, dominated by courses. Consequently, some are initially sceptical about the Aalborg model, but after trying it out this scepticism is reduced to finding the model "Good but difficult".
   The project is a unique motivator, which is highly needed in distance education. As the group members furthermore feel a heavier responsibility for the common project than for the courses, too little time is spent on course work.

Our solutions are:
By adopting new and faster technology and obtaining more experience in how to utilize it, virtual synchronous and asynchronous communication seems to be a reasonable substitute for and supplement to face-to-face communication.
Didactic adjustments provide the students with more time for course work, by a stricter controlled study plan, introducing a project-free period. In addition some of the feelings of group solidarity is attempted transferred from project to courses by compulsory group-assignments. The goal is more communication and collaboration in relation to the courses.
The adjustments are implemented in the basis year program only, as experience from the specializations indicate, that the strict control is no longer necessary.

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