# PBL at Aalborg university

*contributions to the International PBL Conference in Lima July 17-24*

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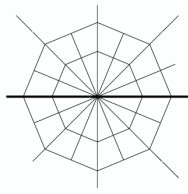

**Technology, Environment and Society**

**Department of Development and Planning**
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**PBL at Aalborg University**
Contributions to the International Conference PBL 2006 ABP


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# Preface

All the articles in this book have been presented at the International Conference PBL 2006 ABP, that was held in Lima, Peru, July 19th-21th 2006.

This conference is part of a series of Pan-American conferences. It is the first time that Aalborg University has participated. At the PBL conference in Lima, there were 8 participants from Aalborg University presenting parts of an Aalborg model. All together we had the responsibility for 11 presentations including keynote presentation and workshop.

We have found it worthwhile to publish these articles together, because there are:

- Descriptions of PBL cases in various disciplines.
- Combinations of development and research.
- Perspectives for future implementation of PBL.
- Perspectives on how to create a global network on PBL.

All the articles have previously been published on the conference cd:
*Congreso Internacional PBL 2006 ABP: International Conference PBL 2006 ABP* 2006, CD-ROM, Pontificia Universidad Católica del Perú, Lima, Peru.

We hope you will enjoy reading the contributions.

Anette Kolmos
Editor

# Promoting and Supporting PBL Interests World Wide

## The Profile of the UICEE Centre for Problem Based Learning

Stig Enemark, Anette Kolmos, and Egon Moesby

# Abstract

The UNESCO International Centre for Engineering Education, Centre for Problem Based Learning (UCPBL) is based at Aalborg University, Denmark, known world-wide for its successful educational approach based on problem oriented project work. Due to more than 30 years of experience in utilising Problem-Based Learning (PBL) in Engineering Education, an increasing number of universities and engineering schools throughout the world are seeking consultancy and cooperation with Aalborg University. The establishment of UCPBL is therefore a timely opportunity to merge the efforts into one organisational structure aiming to promote and support PBL interests worldwide.

This paper presents the UCPBL profile and plan of action. This includes a wide range of activities such as promoting research and development within the various PBL models and their implementation; Education and training in PBL through offering a Master degree as well as single courses in PBL; international consultancy on PBL to support and sustain the process of change at higher educational institutions that wish to renew their educational concepts towards a PBL approach.

UCPBL Centre for Problem Based Learning is currently involved in a number of projects world wide focusing on institutional change toward a more student centred, project organised, and problem based approach to learning. The Centre is also establishing a UCPBL Global Network on Problem Based Learning in order to facilitate better access to and co-operation within the PBL area.

# Introduction

The UICEE Centre for Problem Based Learning (UCPBL) was established in 2001 at Aalborg University (AAU), Denmark as a satellite centre of the UNESCO International Centre for Engineering Education (UICEE) based at Monash University, Melbourne, Australia.

Aalborg University was chosen as the host of this centre due to its world wide reputation of utilising a successful PBL approach especially in Engineering Education. More than 30 years of experience in this area has placed Aalborg University in a leading position of promoting best practice in this area. Consequently, an increasing number of universities and engineering schools throughout the world are seeking consultancy and cooperation with Aalborg University. The establishment of UCPBL is therefore a timely opportunity to merge the efforts into one organisational structure aiming to promote and support PBL interests worldwide.

This paper presents aim and objectives of UCPBL and the various activities in the fields of education, research and consultancies on implementing innovative PBL approached to teaching and learning. As a background, the paper starts by presenting the key PBL methodology applied at Aalborg University since it was established in 1974, and lessons learnt through 30 years of experiences.

# Project-organised and problem based learning

The PBL approach applied at Aalborg University is both project-organised and problem- based. In order to provide for the use of project work as the basic educational methodology the curriculum has to be organised into general subjects or "themes" normally covering a semester. The themes chosen in a programme must be generalised in such a way, that the themes in total will constitute the general aim or professional profile of the curriculum. The themes must provide for studying the core elements of the subjects included (through the lecture courses given) as well as exploring (through the project work) the application of the subjects in professional practice.

*Project-organised* means that traditional taught courses and labs is replaced by project work assisted by lecture courses. The project-organised concept moves the perspective from description and analyzing into synthesizing and assessment. The concept is based on a dialectic interaction between the subjects taught in the lecture courses and the problems dealt with in the project work. Each term has a basic structure containing, in principle, equal distribution of lecture courses and project work. But the study-time is dominated by lecture courses at the beginning of the term and by project work at the end. The project work is carried out by groups of four to six students having a teacher appointed as their supervisor.

*Problem-based* means that traditional textbook-knowledge is replaced by the knowledge necessary to solve theoretical problems. The problem-based concept moves the perspective from understanding of common knowledge into ability to develop new knowledge. The aim of the project work is "learning by doing" or "action learning". The project work may be organised by using a "know-how" approach for training professional functions, or it may be organised by using a "know-why" approach for training methodological skills of problem-analysis and application. The former is normally applied in first half of the curriculum where the necessary disciplines are taught in the lecture courses. The latter is applied in the second half of the curriculum and is supported by lecture courses presenting the necessary theories within the specific professional areas.

The difference between traditional subject-oriented education and this project-oriented educational model may be expressed in short by an old Chinese proverb:

> *"Tell me and I will forget*
> *Show me and I will remember*
> *Involve me and I will understand*
> *Step back and I will act"*

# Learning to learn

The main challenge of the future will be to accept that the only constant is change. To deal with this constant change the educational base must be flexible. Graduates must possess skills to adapt to a rapidly changing labour market and they must possess skills to deal even with the unknown problems of the future. Professional and technical skills can be acquired and updated at a later stage in one's career while skills for theoretical problem-solving and skills for "learning to learn" can only be achieved through academic training at the universities.

A number of research studies (e.g. Coleman, 1998) have confirmed that students retain only 10 per cent of what they read and only 20 per cent of what they hear. However, if a problem is simulated, then up to 90 per cent of the lessons learned may be retained. This finding is behind the shift in the pedagogical doctrine toward project work and problem-based learning. It emphasizes learning instead of teaching. Learning is not like pouring water into a glass. Learning is an active process of investigation and creation based on the learners` interest, curiosity and experience and should result in expanded insights, knowledge and skills (Kolmos, 1996).

A consequence of this shift from teaching to learning is that *the task of the teacher is altered from the transferring of knowledge into facilitating learning.* Project work also fulfils an important pedagogical objective. Student must be able to explain the results of their studies and investigations to other students in the group. This skill appears to be vital to professional and theoretical cognition: *Knowledge is only established for real when one is able to explain this knowledge to others.* In traditional education the students restore knowledge presented by the teacher. When the project organised model is used, the knowledge is established through investigations and through discussion between the student members of the project group, and mainly without the presence of the teacher.

# Lessons learned

A number of lessons are learned through the 30 years of experience at Aalborg University.

- *The graduates possess the skills for solving the unknown problems of the future.* The graduates may be less experienced in solving standard everyday problems as they will appear in a further employment. They are, however, much better qualified to undertake large and complicated tasks, to combine insight from different fields, to analyze new problems and to make them acquainted with new fields to which the problems of practice are related. In principle, it is thus ensured that the graduates have obtained the skills needed to solve also the unknown problems of the future (Kjersdam and Enemark, 1994).

- *Skills for learning to learn are developed through the project work.* This relates to the fact that knowledge established through one's own investigations is far better consolidated and easily applied than knowledge gained from textbooks or lecture courses.

- *Skills for cooperation and management are developed through the process of the project work.* The students are working as a team and thereby develop a range of personal skills in the area of cooperation and management including the need for finishing the work within a given deadline – as is also the demand in professional practice.

- *Cooperation with the trade and industries is established through the project work.* The problems dealt with in the project work are real world problems faced by the trade and industries. The students as well as the teachers therefore interact with the trade and industries for solving the problems posed.

- *Innovative interaction between education and research.* Many new research problems can be identified through the students´ project work and continued in the research carried out by the advising teacher. On the other hand, many of the student projects may be based on the current research activities of a teacher and thus contribute to the development of knowledge in a fruitful co-operation with the teacher. This interaction between education and research constitutes the necessary dynamic element of innovative education.

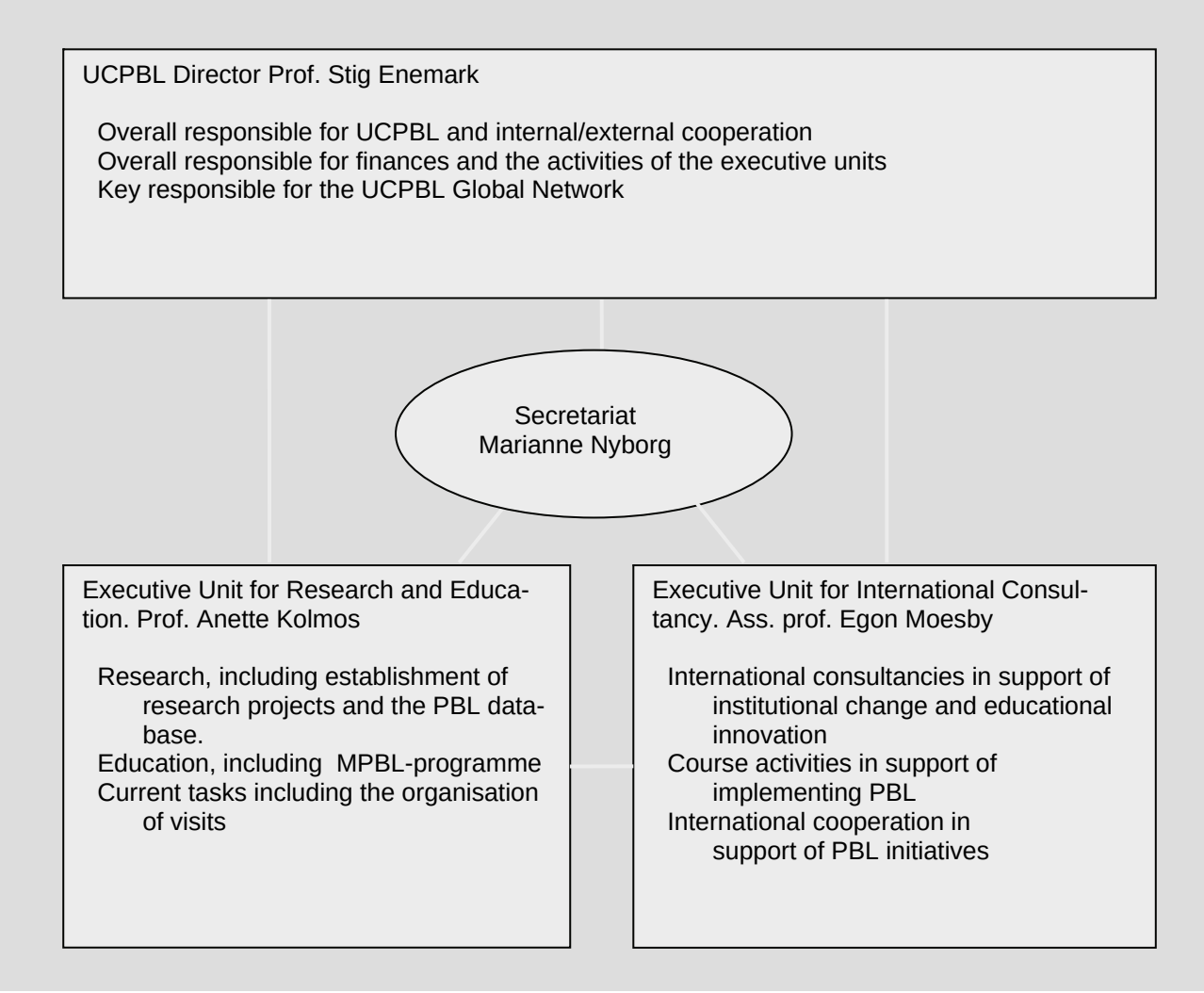
- *A flexible and relevant curriculum is ensured due to the demand for actuality.* The focus on subjects presented in the courses is easily updated or changed to reflect technical and professional development in society. This way, the faculty staff is continuously updated. The focus is on the questions posed by the students, rather than the other way around.

- *The project-organised approach is relatively* demanding in terms of faculty staff resources. This is due to the need for supervising the students in groups of four to six persons. This way, the staff resources are dependent on the number of students.

# The UCPBL profile

The overall objective of UCPBL is to promote and support PBL interests worldwide. This includes research and development activities, educational programs, consultancy activities, and the establishment of a UCPBL Global network for international cooperation and exchange of experiences. The overall profile and the activities of the UCPBL Centre for Problem Based Learning are presented in the work plan that is continually updated and available at www.ucpbl.org/workplan.

*The organisational structure of UCPBL*




The organisational structure reflects the two main areas of activities through an executive unit for Research and Education and another one for international consultancies. This is shown in the diagram above.

# Research and development

The overall goal for research and development is to establish relevant research projects within the field of PBL such as:

- documentation of improved learning for students studying in a PBL-curriculum,
- development of various PBL-models, and
- strategies for implementation of PBL in various organisations.

An important issue in this kind of research is to address intercultural learning and analysis of values in PBL-systems compared to students' cultural values and background. Priority will be given to:

- Establishment of research projects, including establishment of international PhD scholarships especially through the relevant EU-programs.
- Presentation of research results. In 2006/2007 UCPBL will published a book on PBL and change processes from traditional teaching to a PBL-approach in various institutions. The book will contain analysis of these processes and the specific PBL models that has been implemented.

# Education

The overall goal for this area is to launch a Master Program in Problem Based Learning (MPBL) at a global level. The study regulations for this course are formally approved. The MPBL-program started February 1, 2006 with the first cohort of participants. There will be open for next enrolment February, 2007. For further information: http://www.mpbl.aau.dk/

The overall outcome of the master program is for the participant to gain the competences of being in charge of innovative teaching and educational experiments and thereby develop an experimental practice which will lead to continuous improvement of the quality within engineering and science educations.

MPBL is fixed as one work year course (60 ECTS equivalent to one full year of study equivalent to 1800 hours of workload for the student), where one work year is defined as a full-time student's work in one year. The course is, however, based on part time studies and technology supported distance education. As part of the program several lecture courses are offered as single subjects. This is a strategy for recruitment to the total program, as there is normally no formal requirement for 60 ECTS pedagogical training. The structure of the MPBL-program is as follows (1ECTS equals 30 hours of study; P-course is a lecture course relating to the project work; S-course is a lecture course relating the Master Program in general).

The first module is to develop a teaching portfolio in which the participants' reflect on their previous and present teaching experiences and start reflection on PBL.

The development of the MPBL-program is financed by Ministry for Science, Technology and Innovation, Denmark and ERASMUS Curriculum Development Projects, Socrates Program, EU. The following partners participate: Glasgow Caledonian University, Scotland, Hochschule Wismar, University of Technology, Business and Design, Germany, Lucian Blaga University of Sibiu, Romania, Pedagogical Network for Engineering Education (IPN), Denmark.

The long term goal is that the MPBL-course should be able to recruit students at a global level and cooperate with partners in the UCPBL Global Network.

**Programme overview**

*Module 1 - Development of Teaching Competencies*

| | |
|---|---|
| • PBL in Engineering and Science Education<br>• Learning Theory for Engineering and Science Education<br>• IT and the Study Programme<br>• Engineering Didactics | 10 ECTS |
| • *Project – Teaching Portfolio* | 5 ECTS |

*Module 2 - Planning of Teaching Experiments*

| | |
|---|---|
| • Intercultural Learning and PBL<br>• Development of Process Competencies<br>• Scientific Methods in Engineering | 9 ECTS |
| • *Project – Planning a Teaching Experiment* | 6 ECTS |

*Module 3 - Implementation of Teaching Experiments. Specialisation*

| | |
|---|---|
| • IT in Teaching<br>• Evaluation and Quality Development in Engineering and Science Education<br>• Strategies for Management and Staff Development<br>• Supervision<br>• Engineering Competencies in a Global Information Society<br>• Work Based Learning<br>• PBL and Mathematics | 9 ECTS |
| • *Project – Implementing a Teaching Experiment* | 6 ECTS |

*Module 4 - Reflection and Evaluation*

| | |
|---|---|
| • Research Methods | 3 ECTS |
| • *Project – Final Thesis* | 12 ECTS |

# International consultancy

The UCPBL Unit for International Consultancy offers consultancy related to institutional change processes, curriculum development, staff development, and training programmes or topics for institutions entering into a process of change or have already made a change towards Project Organised and Problem Based Learning as the basis of their educational system. The programme can be offered to an entire institution or a sub-institution, school, department, or programme. The consultancy activities relate to the following areas:

- *Consultancy aimed towards the complete process of institutional change.*
  This area covers complete consultancy programs for the total process of institutional change in relation to introduction of a PBL approach. Typically, this kind of consultancy will be long-term agreements covering all aspects of the process of change. The activities are limited to consultancy tasks and not supervision agreements.
- *Consultancy aimed towards specific areas or topics in a process of change.*
  This kind of consultancy relates to specific areas or topics in a process of change, and not the entire process of change.

- *Consultancy for support of curriculum development*
  The activities sustain and support curriculum planning and development and are focused on designing the main educational structure based on local potentials, and whether an existing or proposed educational structure is suitable as a platform for implementing a new educational model based on a PBL approach.
- *Consultancy for staff development programs.*
  The consultancy relates to training and developments in the process of change, and in the structuring of educational programs and their development. These activities are typically carried out prior to the specific course activities listed below.
- *General Capacity Building Activities.*
  The UCPBL Unit for International Consultancy further offers general capacity building activities to develop and sustain education programs and institutions or sub-institutions in their activities related to the introduction of innovative teaching and learning methods. The UCPBL Executive Unit for International Consultancy can act as an active partner in co-financed international projects, supported by e.g. EU, World Bank, Danida or other officially supported projects.

The UCPBL Unit for International Consultancies also offers development and conduction of training and development courses to support and to sustain the processes of institutional change. These include:

- Strategic Level Courses.
- Tactical Level Courses.
- Operational Level.
- Overall introduction courses for all members of the Institution or sub-institution.

Extensive consultancies have been undertaken at Tec de Monterrey, Mexico, to facilitate their process of change. Consultancy contacts are also established with a number of universities throughout the world such as University of Conception, Chile, University of Sao Paulo, Brazil, Chiang Mai University and Siam University, Thailand, Catholic University of Mozambique, Kolej Universiti, Johor, Malaysia, Mondragon Unibertsitates, Spain and University of Victoria, Australia.

# The UCPBL global network

The objective of the UCPBL Global Network is to establish a forum for educational institutions having an interest or being actively involved in PBL activities. The forum will facilitate:

- Information about PBL activities around the world.
- Cooperation and exchange of experience within the PBL area.
- Research activities within PBL.
- Capacity building initiatives.
- Curriculum and staff development activities.

To qualify for membership of the UCPBL Global Network the institutions will need to demonstrate the use of PBL methodologies or that the institution is in the process of preparation or implementation of a PBL approach. The benefits of being a member include:

- Access to the UCPBL on-line PBL Library, that is web based and includes global references to PBL publications, research, and development activities. This way the PBL Library acts as a subject gateway to Problem Based Learning.
- Access to PBL newsletters.
- Access to research cooperation.
- Access to exchange of students and faculty staff.
- Access to bi-annual network seminars.
- Access to self-promotion of the institutional profile of the member institutions.

The UCPBL Global Network will be launched on the web by July 2006.

# Final remarks

The UCPBL Centre for Problem Based Learning was founded in 2001 at Aalborg University which is recognised world wide for the successful implementation of a project-organised and problem based approach especially within engineering education. The Centre is a unique opportunity for Aalborg University to merge the efforts into one organisational structure aiming to promote and support PBL interests worldwide.

The UCPBL Global Network provides a worldwide platform for networking activities in various aspects of PBL including mutual exchange of experiences, education, research, and capacity development through consultancy activities. The objective is to facilitate better access to and cooperation within the PBL area at a global scale.

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**Key Words:** PBL, UCPBL, Problem Based Learning, Project Based Learning.

# Transformation to Problem and Project Based Learning

Anette Kolmos

During the last ten years, Engineering Education has undergone tremendous changes. A lot of these changes were caused by external and internal factors. The external factors such as government policy concerning resources, and educational and quality assurance policies are rather simple to describe. However, the internal factors at the institutional level may be unknown. Institutions have developed many different pedagogical models, using very different strategies for development.

Nearly all Danish engineering institutions have implemented elements of Problem Based and Project Based Learning (PBL). Particularly five Engineering University Colleges have undergone changes towards PBL. The Pedagogical Network for Danish Engineering Education (IPN) has been one of the central agents in the change processes for engineering education in Denmark. IPN has been responsible for staff and faculty development at the engineering university colleges and has been running the co-ordination of the exchange of experiences among all Danish engineering institutions.

However, it is not the same PBL-model that has been developed at the five different institutions – in fact, very different PBL-models have been developed on the basis of very different development processes.

In this article, I will shortly present the results from two case studies. The results underpin the hypothesis that only top-down decisions at institutional level together with a pool of motivated staff will cause changes at a system level. A bottom-up approach with decentralized development at departments leads to a variation within the institution, but it might be difficult to develop curriculum models at system level.

# Introduction

Change in higher education is not a very well-described area. Fullan (2001, 2004, 2005) is one of the few authors who have developed concepts for change in education – primarily based on experience from primary and secondary school. He emphasizes that the outcome is not only student

learning, but also organizational capacity. Students leave the education – the sustainable factor is that the staff has changed in order to constantly develop students' learning and the learning outcomes. Fullan stresses that change is a process, not an event (Fullan, 2001, 2005), and this means that change is not something that can be done overnight. It takes time and it reaches into values and conceptual change (Henriksen et al. 2004).

In order to find a concept of processes of change, one often has to turn to organizational literature, and in that connection, Kotter is frequently drawn upon. Kotter's (1995) model for change is often used to illustrate phases at a more specific level. This model was developed in the context of companies, but has been used as an analytical model for education processes as well (Morgan and Roberts, 2002). Kotter (1995) works with eight phases, see figure 1.

The important aspect of Kotter's eight phases is that he stresses the importance of urgency and the creation of visions. In our experience as faculty developers who are often given workshops on various education topics and with the purpose of motivating staff, staffs do not possess the sense of urgency nor feel that they have a part in formulating visions.

Figure 1: Kotter's eight phases

| Phases | |
|---|---|
| 1 | Establishing a Sense of Urgency |
| 2 | Forming a Powerful Guiding Coalition |
| 3 | Creating a Vision |
| 4 | Communicating the Vision |
| 5 | Empowering Others to Act on the Vision |
| 6 | Planning for and Creating Short-Term Wins |
| 7 | Consolidating Improvements and Producing Still More Change |
| 8 | Institutionalizing New Approaches |

Normally, teachers do not experience any urgency – on the contrary, they feel confident and satisfied with existing teaching practices. Only few staff members feel the need for change. External reasons are most often the trigger of internal institutional change.

In Kotter's version, the vision consists of the leader formulating and communicating the vision to the staff. In educational settings, the role of the leader might be hard to define and fulfil as leaders often are very good colleagues with "their" employees. So the formulation of visions has to be regarded as a common process among colleagues. The vision element is important since the process of visions may include both motivation and an overview of the total planning process (Moesby, 2004).

Change in higher education is much more complicated compared to change in private companies due to the organizational structures and, not least, the role of leadership. In private companies, leaders normally have the power to direct and control initiatives. In higher education, leaders are

normally elected among colleagues and leadership has a tendency to involve administration rather than pointing out future directions. New trends are emerging with appointed leaders in higher education; however, the impact on change is still to be investigated.

Regardless of appointed or elected leaders, Kolmos, Gynnild and Roxå (2004) make the point that all levels in the organization get involved if the organization enters a change process. Bottom-up strategies are not efficient because change at system level requires a decision at top-level. Similarly, top-down strategies are not efficient because they create a lot of resistance in the system. So the optimum situation is to establish change by using both top-down and bottom-up strategies – and research shows that both strategies are needed.

There is a need for change agents – if the change starts from the top, change agents must be found among involved staff members, and if the change starts from the bottom, change agents must be found in the top. The role of change agents is to motivate staff and to lead the change process by pushing the whole time. Pushing for visions – pushing for exact plans – pushing for resources, strategies, etc. We are not saying that each individual change agent should cover all the responsibilities, but experience shows that there must be some drivers (Kolmos, 2002).

There is also a need for faculty development units – and for these units to relate to all levels in the organization - both the top, middle, and bottom levels. However, in order to develop that kind of practice, resources and awareness are needed. Faculty development units can be change agents as well on the general level, but normally they do not have the subject knowledge.

# The Two Cases

Over the course of the past 30 years, a number of radical changes have taken place in Danish engineering education. What is unique about Danish engineering educations is that not only one individual institution, but all institutions over the last ten years have developed their teaching on the basis of student-centred conceptions of learning. We have witnessed an emerging tendency to formulating models and systems, albeit of very different nature. All institutions employ project work of some sort, but the practical implementation and scale of it vary.

Overall, all institutions have been guarded by the same educational-political processes, which are characterized by:

- Transition from technical college to engineering college.
- Continuous cutbacks.
- Merging of institutions.
- Change in organizational conditions from democratically elected structures to hired leaders.
- Introduction of interdisciplinary projects in the 1980s, which has earned the institutions their first project experiences.
- Need for upgrading skills in order to elevate professors to Master levels.
- Joint pedagogical skill development through the establishment of the Pedagogical Network for Danish Engineering Education.

The two institutions where the processes of change have been analyzed are in many ways similar.

- CASE A
- University college
- ~ 1050 students
- ~ 100 staff members
- institutional change in 1998

- CASE B
- University college
- ~ 950 students
- ~ 95 staff members
- Institutional change in 2002

At both institutions, eleven interviews were conducted with former and existing leaders and teachers.

# Case A

Wide-scale project work was introduced at a time when there was still a democratically elected direction. This has a great influence on the process since that type of structure entails limits to how much the direction can manage the process without clear support from the staff. Consequently, interviews with employees at this institution also reflect that they do not remember there being any great resistance to the changes because these were supported by the employees' decisions. However, a few of the employees would have liked to carry through more radical solutions.

Figure 2: Case A - model

| | | | | | |
|---|---|---|---|---|---|
| Semester 1-4 | Course 5ECTS | Course 5ECTS | Course 5ECTS | Course 5ECTS | Project 10 ECTS |
| Semester 5 | Practicum | | | | |
| Semester 6 | Course 5ECTS | Course 5ECTS | Course 5ECTS | Course 5ECTS | Course and pre project 10 ECTS |
| Semester 7 | Course 5ECTS | Course 5ECTS | Project 20 ECTS | | |

Total 210 ECTS (European Credit Transfer System, 1 ECTS=30 hours of students' work):

30 ECTS for practicum
70 ECTS for projects
110 for traditional courses

The model can be described as below. A characteristic feature is the fact that no major merging of courses occurs. A project worth 10 ECTS is introduced, though, on each of the semester 1-4 and 6, and a project worth 20 ECTS on the last semester.

Described in facts, the process of change was as follows:

- 1996-98: they joined several workshops held by IPN on project based learning. Many teachers tried to experiment with project work.
- 1998/99: decision made stipulating that at least 1/3 of the overall time should be used for project work. The decision was made by the senate, which at that time was a democratic forum elected among staff members.
- 1998: rebuilding of the physical infrastructure to allow for groups rooms.
- The internal staff development function was not well-established at the institution – there were only very sporadic, if any, follow-ups after the first workshops in 1996-98.
- The interviewees could not remember any resistance among colleagues.
- No sure indications that the approach to teaching and learning had changed. Projects are mainly regarded as application of the knowledge that has been taught in lectures.

Compared to Case B, the interviewees did not express any particular excitement about their change. This could be ascribed to several factors, for instance, the fact that a substantial time had passed since the change occurred and therefore, perhaps, they were unable to remember it in detail. But it also has to do with this institution having undergone a process of change initiated by a newly hired leader, who did not find the employees of the institutions properly prepared for the new changes.

# Case B

At institution B, the changes were implemented at a later stage when it had become managed by a hired direction. The leader who was hired came from the department where project work was carried out already in the mid-90s. With the elected direction it was chosen by the direction that a reform was to be implemented, and direction set up a committee to lead this work. The model can be described as below, figure 3. A characteristic feature of this process was the fact that smaller courses were grouped together in bigger professional units.

The process can be described as follows:

- 1996-2000: several training workshops on project work were held.
- Late 90s: electronics and mechanics started to implement elements of PBL - but very different approaches to it. Electronics had some very enthusiastic staff members. The other department did not have PBL to the same degree as Electronics.
- 2001: new leader was appointed – he came from electronics.
- 2002: cuts in resources - decision was made to develop a model – very much based on the experiences from electronics. Group rooms were build.

- The decision was a top-down decision – and a group of change agents were pointed out to lead the actual transformation process.
- There was a strong internal staff development unit to support the idea.

The process of change in institution B involved additional elements. In part, new goals for development of students' process competencies were formulated in connection with the introduction of project work. In part, experiments were carried out involving the use of formative assessment methods in courses, and, not least, experiments concerning the timing of the relationship between courses and project.

Figure 3: Case B - model

| | | | |
|---|---|---|---|
| Semester 1-4 | Course | Course | Project 10 ECTS pr. semester |
| Semester 5 | Course | Course | Project 20 ECTS |
| Semester 6 | practicum | | |
| Semester 7 | Project normally with a company 30 ECTS | | |

Total 210 ECTS: (European Credit Transfer System, 1 ECTS=30 hours of students' work):

30 ECTS for practicum
90 ECTS for projects
90 for traditional courses

Finally, the committee in charge of the process of change formulated a number of visions, philosophies, and values to accompany the new models.

The interviews demonstrated that the interviewees were incredibly proud of their process of change. They held their own understanding of the model and the underlying pedagogical concept. At first, this phenomenon occasioned a great deal of reflection on the interviewers' parts, but along the way, this came to be interpreted as a positive expression of the personal internalization of the pedagogical processes of development.

Institution B also experienced resistance - around 20% of the interviewees from this institution did not wish their interviews to be recorded – but they clearly expressed that they "just did as they had always done, only now it was called something new, but in reality it was not new at all." To questions of why they kept doing like they used to, the typical reply was "that the students are unable to learn this profession in any other ways."

Institution B is well aware of the resistance – and has chosen to ignore it this time around. As long as this does not cause any student complaints, the direction will disregard it. But at some point, it will be dealt with.

# Comparison and Perspectivizing of the Two Cases

A process of change is not initiated without the presence of external causes. External causes have influenced both institutions, albeit at different points in time. Extensive institutional changes rarely occur without an external pressure since many resources are involved.

The two institutions have had very similar conditions of change, but the processes of change have taken place at very different times and under different managerial structures. At institution A, change took place under a democratically elected direction that has had no intention of causing division in the organization, but instead has set realistic goals for the processes of change. This way, they witnessed a bottom-up approach that led to a managerial decision on top-level. However, we here see a model that is not far-reaching in its endeavours to implement a different pedagogy. The institution still holds a series of individual courses with individual exams and no attempt to integrate courses and project.

Institution B has, in the case of one department, had a pattern similar to that of institution A. Institution B consists of two departments, one of which already in the mid-90s reorganized the educations to contain project work, whereas the other department has had much more sporadic experiences with project work. When a new direction was being hired, the direction became dominated by people from the department that already had adopted the project work, and it was agreed that the entire institution was to develop a common model for teaching. Here, we are dealing with a bottom-up approach since one department already has set out the course, but simultaneously, with a top-down approach as the newly hired direction makes the decision to make it apply to the entire institution. If a democratic process had been allowed to be the basis for decisions in the department that had not adopted PBL, the decision to implement the model might not have been as far-reaching.

Both cases demonstrate that only top-down decisions at institutional level together with a pool of motivated staff will cause changes at a system level. A bottom-up approach with decentralized development at departments leads to a variation within the institution, but it might be difficult to develop curriculum models at system level without the top-down decision. For universities in some countries, this conclusion might seem banal – but in an European context, this is a very important result.

Figure 4: Change processes

| Phases | Kotter, 1995 | Case A | Case B |
|---|---|---|---|
| 1 | Establishing a Sense of Urgency | External reasons<br>Cuts in resources | |
| 2 | Forming a Powerful Guiding Coalition | No | yes |
| 3 | Creating a Vision | Absence | There is a process of formulation visions – but not all staff members participate |
| 4 | Communicating the Vision | | |
| 5 | Empowering Others to Act on the Vision | | |
| 6 | Planning for and Creating Short Term Wins | yes | yes |
| 7 | Consolidating Improvements and Producing Still More Change | There is a tendency to stop | |
| 8 | Institutionalizing New Approaches | This has been done at both institutions | |

Institution B also managed to develop a more holistically coherent education. Through the process of change, the institution succeeded in getting a more qualified staff to have a vision for their own processes of change. This does not include all staff members, however, since approximately 20% of them are very negative towards the changes that have taken place.

Looking at the results from the two cases in terms of Kotter's eight phases, see figure 4, more effort and attention could definitely have been devoted to two phases. Phase 1 involves a sense of urgency, and no one in either institution really feels this. Most see the changes as being necessary because of financial reasons and not because the students are to learn new and different competences. Even though in institution B there has been talk of formulating new competences, the need for this has not been the guiding factor for the individual employee. The common perception was that it was simply necessary to do.

No vision has been formulated at institution A as there has at institution B – even though everyone has not taken part in that process. But both institutions tend to stop the process of change – no new energizers enter the process. Nonetheless, it is important to conclude that both institutions have developed models, and they have succeeded in institutionalizing the changes by, for instance, altering the physical infrastructure.

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# Democratic Elements in Group and Project Organized PBL

Democratic skills and bildung via project organized problem based learning in groups in the Aalborg Model. Results from a pilot investigation.

*Palle Qvist*

# Abstract

Students in a democratic learning system as the Aalborg Model knows of and uses democratics skills as e.g. the ability to discuss and accept other points of view, negotiate, compromise, reach consensus or accept the result of a vote in striving to reach specific common or personal learning goals, run processes and decide behaviour. It is what a pilot investigation referred in this article indicate.

The meaning of this seems to be far behind the study itself and qualifications of the students to the labour marked. If it is true that ”the building of community begins in the classroom but extends beyond it to the school and the community” (Marris, 2003:274) then implementing democratic learning systems as The Aalborg Model are important for supporting and promote democratic bildung of students in higher education.

This article defines at a – start - what should be understood by a democratic learning system. It contrasts it to an authoritarian or elitist systems. Then it brings the results from an investigation of 9 process analyses’ written at the end of the second semester 2005 by project groups from The Technical Natural Scientific Basic Year at Aalborg University and concludes that students make decisions related to learning and learning goals, learning processes and behaviour after discussions and so called rounds which indicates hat they develop democratic skill useful in social relations.

# Democratic learning

Democratic learning can tentatively and in general be defined as learning in a system which supports democratic principles together with reaching the learning outcomes. The meaning of democratic principles must be further defined.

Democracy is a positive word in the western culture. The word means rule by the people.

Christensen and Jensen differ between democracy as goal and as means.

“Looked at as goal it is normal an element in a strategy of liberation – as a normative demand for everybody to have maximum influence on affairs which matters for them. But it can also be seen as a method to reach common decision on important issues in a reasonable way. What is meant by ‘common’ is that all people involved have the same influence at the starting point which also means that decisions are supported broadly afterwards. Democracy can be a method to avoid heavy conflicts concerning political issues” [Note 1] (Wrang og Jensen, 2001:135)

The academic literature about democracy has many definitions of democracy. Or more precisely definitions of different forms of democracy (see the reference list). In the conventional understanding called the liberal or economic model democracy is a political process containing individual preferences to be settled in a fair and just way.

Miller has written:

”In the liberal view, the aim of democracy is to aggregate individual preferences into a collective choice in as fair and efficient a way as possible. In a democracy there will be many different interests and beliefs present in society. Each person’s preferences should be accorded equal weight” (Miller, 2000: 9).

Raphael writes about the choice of each individual:

”The underlying idea is that self-direction, choosing for yourself is far preferable to having decisions made for you, and imposed upon you, by another... “ (Raphael, 1970: 144).

In the communicative understanding of democracy creation of opinions is an important part of the process and expression of democracy.

An example is the Danish theologian Hal  Koch (Koch, 1945) and the German philosopher and sociologist Jürgen Habermas (Habermas, 1981, 1996). Koch has described the essence of democracy as conversation, dialogue and discussion with the aim to reach consensus about the common goods. (Koch, 1945).

Habermas talks about deliberative democracy and the ideal behind is the ethics of discourse. In a communication community, free and without supremacy, is it according to Habermas possible to reach a common understanding, assuming, that basic rules are respected.

The rules are: Everybody has the right to participate in the discourse, everybody has the right to introduce any subject and everybody has the right to question any allegation. Nobody should be limited in using these rights.

Habermas formulates two principles for decision making. The principle of discourse and the idea of communicative freedom. According to the principle of discourse only decisions and acts which everyone affected has agreed on, are valid. A decision is legitimate when everybody has agreed. Communicative acting means that the participants in a discussion has as goal a common understanding – contrary to a situation in which they act strategic and try to reach e.g. individual goals or goals which favours the few.

Habermas is just one of many scholars trying to define the concept deliberative democracy (Miller, 2000). Elster has tried to sum up the different approaches to a common definition of participatory democracy. (Elster, 1998)

He admits that the ”characterizations are somewhat rough”, and continues:

”There is a robust core of phenomena that count as deliberative democracy …the notion includes collective decision making with the participation of all who will de affected by the decision or their representatives: this is the democratic part. Also ... it includes decision making by means of arguments offered *by* and *to* participants who are committed to the values of rationality and impartiality: this is the deliberative part” (Elster, 1998: 8).

Drawing on the literature and the scholars above important democratic principles seems to be:

Decisions including settling of disagreements are reached by arguments (discussion) or negotiation (dialog), voting or consensus (see also Elster, 1998:7) (or a combination) between those affected by the decision. The participants are in principle equal with equal rights and feel themselves committed to the values of rationality and impartiality.

It is implied that decisions and settlements are respected and identical actions are taken. Decisions, settlements and actions can always be questioned but must be respected until new decisions between the participants are reached.

*More precisely democratic learning* can now be defined as *learning in a system where decisions, processes and behaviour related to learning are established through argumentation (discussion) or negotiation (dialog), voting or consensus (alone or in combination) between those affected by the decision simultaneously reaching the learning outcomes, the technical and professional knowledge and insight. The participants must in principle be equal with equal rights and feel themselves committed to the values of rationality and impartiality*.

# Conventional teaching and bildung

Conventional teaching in higher education – e.g. lecturing by a university professor – can be seen as a contrast to democratic learning. It is characterized by the fact that the professor is in control of the lecture. The professor controls the teaching due to the one way communication and the students looks after the right answers from the professor. Learning is for the students a question of finding out what is right and what is wrong. And the professor has the answers.

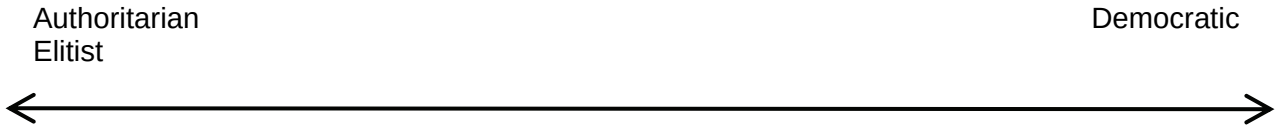
The professor has a specific subject area in which he lectures. The professor controls the teaching not even by the way of communication but also by being the one representing the knowledge and insight on the subject area. The teacher can choose to argue for his understandings, ideas, viewpoints or conceptions. But he can also without any arguments against and because of his authority and documented knowledge on the subject area refer to his technical or professional expertise.

In professor centred teaching it is the professor which - as an authority representing the professional knowledge - has chosen what to teach in (within the given frames). And there are only few situations with possibility for the students to search alternative knowledge compared to the knowledge which the professor presents.

In conventional, traditional professor centred lecturing the student is an object. Not an arguing, searching, selecting and acting subject with influence or responsibility on own learning. In the learning situation the student is passive. The knowledge comes to the student from the professor. [Note 2]

Bildung which is created in conventional systems with characteristics mentioned above can not be called democratic but rather authoritarian or elitist. The relation between authoritarian/elitist and democratic learning and bildung can be shown on a dichotomy.

Figure 1: Authoritarian or elitist bildung as contrast to democratic bildung.




Authoritarian/elitist bildung can be authoritarian/elitist in different degrees. The more to the left, the more authoritarian/elitist. It is the same for democratic bildung. The more to the right, the more democratic bildung elements are in the system.

Many institutions in higher education – also engineering and natural science – are dominated by professor centred or elitist teaching. According to Romme structures determines behaviour (Romme, 1999) referring to the Dutch engineer and entrepreneur Endenburg (Endenburg, 1992).

"The way a system is structured determines the behavior within that system ... Moreover, some structures are more useful and effective than others in leading to certain desired behaviors or outcomes". (Hommes et al. 1999: 115).

Learning in a conventional professor centred system has many supporters but it is hardly - and opposed democratic learning systems – creating democratic personalities (Endenburg 1992).

# The PBL study group, discussions and rounds

Some learning systems have few democratic elements, others have many.

Within participant directed, group- and project organized problem based learning it is – in its ideal form - the members of the study group – the students – making decisions about the problem to settle and how it should be done. (Illeris, 1974). In the ideal form a study group is an independent and autonomic unit. The group has a common vision, goals, strategies and plans. They use and share theories, methods and empirical data and have agreed on common arrangements about rules of behaviour for the group. Some of the important rules of behaviour are related to meeting hours in the group room. It is also agreed that everything can be discussed, how serious the learning should be, how reflecting, constructive and result orientated. Each group member is equal and a resource and everybody participates in the effort to reach common goals formulated by the group e.g. the professional project report (Qvist & Spliid, 2004).

A study group is in principle a communication community, free and without supremacy. It is autonomic and unlimited in relation to planning of its learning within the frames decided by the study board and determined in the curriculum. But limited by the fact that the group at the exam are confronted with and made responsible for selections and decisions during the learning process.

Learning is democratic in the ideal form of participant directed, group and project organized problem based learning [Note 3]. The students decide and plan their own learning in a communication community in the group room, free and without supremacy. They make decisions about learning, learning outcomes, learning process and behaviour after argumentation (discussion) or negotiation (dialog), voting or consensus (alone or in combination) between the group members. In principle they are equal with equal rights. It is presumed that the students when they ague, negotiate and make deals feel themselves committed to the values of rationality and impartiality.

Discussions and “rounds” are methods which support democratic learning. Dillon (Marri, 2003) defines discussions as:

”a particular form of group interaction where members join together in addressing a question of common concern, exchanging their knowledge or understanding, their appreciation or judgement, their decision, resolution or action over the matter of issue (Dillon, 1994: 8)”.

Discussions as pedagogical method are recommended by many (according to Marri, 2003 e.g. by Engle,1988; Hahn, 1998; Oliver & Shaver, 1966; Parker 1996a; Singer, 1997). The reasons are:

1. It can help young people develop the group discourse skills and dispositions necessary for participatory citizenship in a multicultural democracy.
2. It enhances critical thinking.
3. It deepens understanding of important democratic issues and concepts.
4. It develops a more democratic classroom community.
5. It influences future political participation."(Marri, 2003: 273f.)

A leaning system with lots of possibilities for discussions before technical or professional decisions or decisions related to the process or behaviour where the students have possibility to express themselves freely indicates a democratic learning system.

Rounds are a specific form for discussion or dialogue practised by groups. Typically each group member gives his opinion to the subject on the agenda. A moderator or chairman ensures that everybody participates. A referee takes notes – important viewpoints or decisions. The goal is to reach a common understanding between the group members. The moderator sums up after the first round. The purpose of the summing up is to clarify where the group agrees and where the members disagree. In case of disagreement the subject must be discussed or negotiated again in a new round.

The goal of the second round can be searching for a common understanding or compromise, in order to find out what is acceptable for everyone or to find out which decision satisfies most members. The second round can also be more discourse in order to make an effort to agree upon the subjects in which they disagreed upon in the first round. In the third and the following rounds the goal is to reach a common understanding. This can be established after negotiation, be consensus or a result of a vote.

Technical or professional decisions are typical discussed afterwards with the supervisor. The same are decisions related to the process. If the supervisor object to the selections or decisions made by the group they must discuss the matters again. Arrange new rounds with the purpose to find solutions or reach acceptance which can resist technical or professional critique from the supervisor.

Solutions and decisions related to process and behaviour can be group related. They are implemented without being discussed or confronted with the supervisor. They are related to the internal life or wellbeing of the group. The group are responsible for evaluating and reviewing the solutions or decisions.

While discussions in principle are open and unstructured, rounds are relatively structured.

# A pilot investigation

An examination of 9 process analyses [Note 4] written at the end of the second semester 2005 by project groups from the cohort group called Industry on The Technical Natural Scientific Basis Year shows (implicit and explicit) that the groups have discussed and reached agreement on the following technical, process and behaviour matters:

1. Technical and professional goals for the project report.
2. Principles and goals related to sharing of knowledge.
3. Planning of the learning process.
4. Organizing the internal cooperation in the group, including a written agreement on cooperation containing principles of social behaviour.
5. The use of human resources external to the group as e.g. supervisors and contacts within industry.

In their process analyses the groups uses words as ”conversation”, ”consensus”, “broad agreement”, “decision”, “agreed on”, “vote” and “dialogue”. However it is not possible to say that the words reflects and respects the democratic principles described above. More research e.g. interviewing of group members are needed.

8 out of 9 project groups or 89% (85% of the students in the cohort) write in their process analyses’ that they use rounds. It is not possible to confirm that the method described above has been followed 100%. Other rough structured models or more discourse like method might have been used. It is therefore not possible to say anything about the quality of the rounds.

Rounds has according to the process analyses been used in relation to general decision making and setting up of technical goals as well as goals related to project management, to facilitate reflection from other projects groups including communicating experiences, personal visions, personal expectations and personal goals. In relation to project management the groups states that they use rounds when planning, making decisions and solving conflicts.

# Conclusion

Conventional teaching systems determine authoritarian or elitist bildung and behaviour while democratic teaching systems determine democratic bildung and behaviour.

A democratic teaching system is a system with democratic elements. It is a system where decisions, processes and behaviour related to learning are established through argumentation (discussion) or negotiation (dialog), voting or consensus (alone or in combination) between those affected by the decision simultaneously reaching the learning outcomes, the technical and professional knowledge and insight. The participants must in principle be equal with equal rights and feel committed to the values of rationality and impartiality.

The Aalborg Model is an example of a democratic teaching system although not 100% democratic. The influence of the students own learning is not extended to e.g. the teaching in courses and the supervision of the groups might be elitist. But the learning in the groups during the project work is in principle learning in a communication community, free and without supremacy. The students are responsible for their own learning and behaviour within the frames decided by the study board and elicited in the study regulations. A small pilot investigation of 9 process analyses written by students at the second semester of The Technical Natural Scientific Basis Year shows that the students make decisions related to learning and learning goals, learning processes and behaviour after discussions and rounds.

The empirical evidence from the 9 process analyses is not comprehensive enough to generalise about how the Aalborg Model are practised at the entire university. More research e.g. observations of the student's behaviour in the group rooms, interviews with students along with questionnaires and focus group interviews must be carried out.

Because structures determine behaviour the student in a teaching system as the Aalborg Model develop democratic skills useful in social relations. As Marri writes:

"students are able to continue their participation in small publics working toward a national civic culture, a large public" (Marri, 2003: 274).

[Note 1]
Translated from Danish by Palle Qvist.

[Note 2]
On top of that the general view of researchers is that lectures are not the ideal pedagogical method for enhancing the development of effective thinking skills or academic motivation (Cameron ed., 1993). The disadvantages include according to Cameron:

"(a) placing students in a passive role, and thus hindering learning, (b) encouraging one-way communication from lecturer to student, but not vice versa, (c) requiring a considerable amount of unguided student work outside the classroom for understanding and long-term retention of content, and (d) requiring the lecturer to have or to learn effective writing, speaking, and modelling (of effective thinking) skills" (Cameron ed., 1993: 15).

The strong point are (according to McKeachie): " (a) providing up-to-date information on current research and theories relevant to topics being studied, (b) summarizing widely scattered material, (c) adapting material to particular student backgrounds and interests, (d) building cognitive structures and expectations to help students read more effectively, and (e) modelling the motivation and intellectual curiosity of the lecturer" (Cameron ed., 1993: 15).

According to Cameron others list the following advantages of the traditional lecture: “(a) disseminating unpublished or hard to find material, (b) allowing the lecturer to precisely determine the aims, content, organization, pace and direction of a presentation, (c) introducing students to a topic or subject area, (d) complementing and clarifying text material, (e) communicating easily to large numbers of students, and (f) providing a highly teacher-centred teaching methods for students who prefer this method of presentation” (Cameron ed., 1993: 15-16).

[Note 3]
Group and project work obtain only a part of the students learning hours. Even if it in its ideal form is democratic it can easily in practise be organised elitist. E.g. regarding the supervisor or dominating group members. An important precondition (although no guarantee) is that the group uses procedures for decision making which respects the integrity of each group member - respecting the right of each member of the group to take part in discussions, its right to introduce whatever subject and the right to question whatever allegation. Nobody must have these rights restricted or neglected.

Students in a group and project organised learning system receives normally technical and professional supervision. In the Aalborg Model its approx. 1-2 hours a week per semester. The supervision can be elitist or democratic or forms in between. It can be liberal or laissez faire and make room for discussions, choices and decisions between the students.

Besides receiving supervision the students follow courses and work in laboratories.

About 50% of the study time is group learning. The courses are typical conventional elitist university teaching which means lectures planed by the professor and mostly one way communication (see above) with or without tasks for the students to settle. The courses, their content in headlines and outcomes are decided by a study board, where the students have democratic influence through their elected representatives as in a liberal democracy. Indirectly the student has the possibility of influencing the courses, content, outcome and pedagogic via evaluations carried out. In praxis it means that the students have the possibility to evaluate the teaching e.g. via a questionnaire or as member of a focus group.

The teaching e.g. the substance of the courses can eventually be changed by the study board or by the professor – both in relation to technical content or in relation to the pedagogic. This will not always happen. A study board can make the decision not to change a course by voting.

[Note 4]
A process analysis at the Technical Natural Scientific Basis Year at Aalborg University can be seen as a document from the study group proving that it can plan and carry out a learning process of its own. It documents that the group has learned to learn. It uses concepts central to understanding of the learning process and goals. Decisions and non decisions are argued. It contains between others chapters about vision and goals for the learning, plans and time schedules, internal and external communication and cooperation and conflicts. The analysis is a paper of maximum 10 pages exclusive appendix.

The following can characterize the analysis: It contains description, analysis and evaluation of goals, reflections, argument decisions and trials.

Description and analysis are separated and descriptions are documented.

Analysis is separated from evaluation and conclusion. It contains argument advices for the future.

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# Developing Intercultural Competencies in a PBL Environment

Xiangyun Du and Carsten Jahn Hansen

# Abstract

This paper discusses the influences of international programs in a problem based, project and group work organized learning (PBL) environment on the development of intercultural competencies. Based on the discussion of the positive effects as well as the observed barriers in the educational practice of international programs, this paper suggests that PBL can be a good example of a supportive learning environment in terms of providing students opportunities to develop intercultural competences. However, in order to make the best of international programs as an intercultural learning context, it is important to 1) establish a shared understanding of 'international', based on which, new values and practices can be established instead of merely applying the established Danish ways of studying, 2) to bring about more awareness that international programs should be beneficial learning contexts in which students from different cultures can learn from each other and develop intercultural competencies together.

# Introduction

Under the impact of globalization, higher education in the 21st century faces new changes - to orient towards global markets, which means to prepare the students with competencies of working in intercultural contexts. In engineering education, requirements of developing these competencies have been reflected in the accreditation of engineering programs in different countries. As can be cited from the program outcomes and assessment in the Accreditation of Engineering Programs in the U.S. (ABET 2000), 'applied science programs must demonstrate that graduates have … (g) an ability to communicate effectively, (h) the broad education necessary to understand the impact of solutions in a global and societal context…' Similar statement can also be found in the accreditation of European Engineering Programmes and Graduates (ERU-ACE 2005) and the study guidelines for study programs in Danish engineering education (AAU 2003).

Following both of them, in this paper we define intercultural competencies as capabilities of 'working in an international environment with appropriate consideration on differences in culture, language, and social and economic factors'.

How can universities prepare students with intercultural competences? In the Danish context, there have been two related educational practices: 1) to encourage Danish students to go abroad for short-term (one semester for example) study experiences; 2) to establish international programs and invite foreign students to study in Denmark. This paper will only focus on discussing the second practice.

The problem based, project and group work organized learning (PBL) environment has been implemented in some Danish universities for about 30 years. The most important innovative aspect of PBL educational concept is 'the shift from teaching to learning, and consequently the task of the teacher is altered from the transferring of knowledge into facilitating to learn (Kolmos 2002)'. It particularly provides chances for students to communicate and collaborate through working on projects in groups. In the study programs for Danish students, it has been identified as an efficient way of educating engineering students with not only technical skills but also social skills like communication, management and organization (Du 2006).

At the international programs, students are provided opportunities to learn in an intercultural environment, when they do project work in teams that are made up of students with different cultural backgrounds. In this sense, international programs in a PBL environment can be assumed to be an effective milieu in which all students can develop intercultural competencies in their learning process. However; experiences from the current educational practice showed that it is more complex than what has been expected.

This paper aims to examine the influences of international programs in a PBL environment at Aalborg University (AAU) with focus on the development of intercultural competences. Based on empirical evidence that is drawn from both teaching and research experiences, this paper discusses the positive effects of international programs in a PBL environment as well as the observed barriers in the development of intercultural competences. As a conclusion, this paper suggests that PBL can be a good example of a supportive learning environment in terms of providing students opportunities to develop intercultural competences. However, in order to make the best of international programs as an intercultural learning context, it is important to 1) establish a shared understanding of 'international', based on which, new values and practices can be established instead of merely applying the established Danish ways of studying, 2) to bring about more awareness that international programs should be beneficial learning contexts in which students from different cultures can learn from each other and develop intercultural competencies together.

# The application of PBL concepts to educational practice

The theoretical departure for the understanding of PBL derives from the constructivist-sociocultural approach in terms of understanding and examining learning and education, which in the past decade have played a prominent role in the educational development in western countries (Jarvis et al. 1998). The general belief is that learning takes place from the interaction between the individuals, and it is a changing process in a certain sociocultural context. In relation to the application of PBL concept in educational practice, this approach helps to promote the recognition that learning processes will cover the formation and transformation process of a self, and with knowledge and ability of cooperating, reflecting and coping with society in general (Henriksen 2006). In this way, education and learning is related to a broader social transformation in the process of globalization and in the development towards a knowledge society.

The PBL concept has various definitions and ways in application. In relation to engineering education, PBL concept is regarded as a successful and innovative educational method for engineering education (Graaff 2001). Graaff and Kolmos (2003) formulate three common approaches characterizing PBL: learning – content – social approaches.

The **learning approach** refers to three aspects: learning is organized around a) *problems,* because the formulation of them allows the learning contents to be related to b) *the context*, and in the learning process, c) *experiences* are especially important in relation to which problems the student is attracted to on the basis of his/her own understanding and interests.

The **content approach** concerns three aspects as well: a) Interdisciplinary learning. It relates to the dimension of knowledge as the solution to the problem formulation, which may span across traditional subject-related boundaries and methods. This principle is critical for the organization of the teaching because teachers often consider objectives within the known subject-oriented framework, rather than problems or situations. b) Exemplary practice. It is concerned with ensuring that the student's learning output is exemplary in accordance with the framework of the objectives. This is an extremely central principle because the student must engage in a deeper understanding of the selected complex problem formulation. c) Theory-practice. It means that the students gain abilities to analyze problems by using theories. During the entire learning process, they learn the art of analysis as they are required to analyze problems, analyze solutions, develop solutions, and analyze the impact of given solutions.

The **social approach** refers to team-based learning which means that the majority of the learning processes take place in groups and teams. It underpins the learning process as a social act where learning takes place through dialogue and communication. Students are not only learning from each other – they also learn to share knowledge and organize the process of collaborative learning.

In the context of Aalborg University, Denmark, the learning principles of the PBL Aalborg Model is founded on problem-based project work, in which approximately one half of the students' time is spent on project work in teams, whereas the other half is spent on more or less traditional lectures. The project work is formulated within the framework of a given theme, related to the overall educational objectives, which can be a broad, open theme or a subject-related limited theme. The students are allowed to formulate their project proposal themselves, but there will always be a supervisor, who approves the proposal. All project work is made in groups, and the same model is followed from the 1st semester until the completion of a masters' degree. During the span of the university degree programme, the groups normally become smaller, starting with typically 6-7 students in the 1st year and reduced to approximately 2-3 students in the final semester. Each group has one or several supervisors. The role of the supervisor is to give response to the students' project process along the way and not least to run the examination.

The PBL environment has been identified as a supportive learning milieu in which students are provided opportunities to develop active learning, self-directed learning and meaningful learning. In this learning process, students do not only gain scientific knowledge, technical skills, but also capabilities of managing project and team work as well as professional responsibilities in order to prepare themselves for the workplace (Du 2006).

# Resources of empirical evidence

This paper aims to examine the influence of international programs in a PBL environment on the development of intercultural competences. Empirical evidence of this paper is drawn on both teaching experiences and research work with an aim of understanding and promoting intercultural teaching and learning. Resources that are used in this paper are mainly from international programs at two engineering departments at Aalborg University (AAU). Empirical data are mainly from 1) teaching experiences in Project Organized Learning (POL) courses in the department of Electrical and Electronics Computer Engineering. POL course aims to provide foreign students with learning tools when studying in PBL environment; 2) teaching experiences as well as a survey conducted in a master program in Urban Planning and Management; 3) qualitative interviews and observations of selected project groups in both of the departments.

# Findings and discussions

The current international programs at Aalborg University provide 2-year-long education, in which students are expected to do about 3-4 projects before they can be awarded a master degree.

With the participation of students who come from different countries in the world, the learning environment turns more and more international.

In this sense, international programs in a PBL environment can be assumed to be an effective strategy regarding facilitating intercultural competencies for all students. However; experiences from conducted educational practice showed that it is more complex than what has been expected.

The following discussion fall into two aspects:

1) What are the influence of the PBL environment on the development of intercultural competencies?
2) What are the issues and problems arising in the processes?

# Influence of the PBL environment on the development of intercultural competencies

Both teaching and research experiences show that the PBL environment has similar as well as different effects on foreign students and on Danish students in the learning processes.

## Positive effect on foreign students

The major influences on foreign students lie in the new methods of learning and the international context. For the majority of them, it is the first time to study through doing projects in groups. Based on their reflections, this method provides them challenging and constructive learning experiences in an international context.

At the beginning of each semester, students form project groups (normally from 2-6 students in each group) based on their shared interests in solving professional problems. To get the project started, students need to search for the information on the background and context, to find relevant literature, to read theoretical articles, to discuss with supervisors or people who know the area, and they might also need to contact industries or companies for interviews or observations to gain field knowledge. When they have collected enough material, they start to analyze the situation and formulate the problem. The next stage is to find out how to solve the problem and choose one of the solutions, and this involves the same procedures of searching, reading, discussing and writing. In this process, they are facilitated with the knowledge from literature, lectures, and supervision; however, they are expected to relate these different knowledge resources to their project. They need to develop different strategies to gain theoretical knowledge, methods, and context knowledge in order to solve the problem. Instead of following the procedures designed by the teachers, students are expected to manage the project planning on their own.

Picture 1

Picture 1 shows how a group of international students work together in their project room. They use blackboard as assistance in their discussion in order to avoid unnecessary misunderstanding in communication since the English language is not the first language for any of them. Everybody writes down their thoughts on the blackboard to explain how they understand and suggest things.

In general, working in groups provides sufficient chances to share information. Peer learning through group discussion is identified as an effective way of studying technical things. Collaboration in the group work also helps to encourage participation and promote the sense of responsibilities. They bring in different values into the shared practices from the reflection on their past experiences from different contexts. Group work involves discussing, reaching agreements, writing, etc. which demands the awareness and skills of communication, cooperation and management. During an interview with the students in a group (see picture 2), they summarized what they have learned in the process of working on group projects: 1) new angles of looking at things, 2) better understanding of different approaches to tasks based on different educational backgrounds and cultural backgrounds, 3) methods of handling different situations, like being patient with others, dealing with disagreement by compromising, being both organized and flexible, etc.

Picture 2

However, there is a progression during the study from having difficulties understanding why doing project in groups to thinking of this study method as a positive learning resource. In this processes, students learn to learn from mistakes and experiences. Longitude teaching experiences show that external assistance on reflection can speed up this progress and reduce difficulties for students. In the Master programs at Department of Electrical, Electronics and Computer Engineering (EE), curriculum for the first semester is focused on learning how to learn in the PBL environment. As beginners, students are also provided a course named Project Organized Learning, which aims to provide introduction to PBL concepts and practices in the context of AAU. In addition, students are also provided knowledge as well as tools for cultural differences in communication and learning, project planning, learning methods, collaboration and cooperation in team work (for example how to provide constructive comments, how to handle disagreements, and how to reach positive communication etc). POL courses are provided hand-in-hand with the process of the first project. In this way, students learn to develop project management systems through team work along the way of doing the first trial.  This course has been evaluated by the foreign students as a useful tool in the process of getting used to the PBL learning environment.

## Positive effect on Danish students

Learning through doing projects in groups is in general identified as a beneficial way of learning by Danish students (Du 2006). At the Danish programs, discussions in the group regarding how to relate information from lectures and textbook knowledge to the project work provide a context to understand technical contents in a deeper and more meaningful way. Peer learning through shared practice is appreciated as an efficient learning strategy in terms of sharing information resources and getting inspiration. Good atmosphere and successful cooperation is specially recognized as great motivation to get work done and to achieve the goal of learning. When reaching the master level of education, Danish students are expected to participate in international programs because it is a good opportunity to study in an international environment without having to travel.

The practice of the International Master Program in Urban Planning and Management (UPM) provides a good example of attracting Danish students to participate in project work in international groups. With the expectation of knowing more about other cultures, they have positive attitudes in the process of group work during the first semester. Based on their reflection, foreign students bring in different ways of working, which provided chances to reflect and rethink their established ways of doing group work. This brings about constructive challenges to their established ways of thinking and learning.

# Challenges and identified barriers

In spite of the constructive influences, there have been observed different problematic issues that have brought about difficulties for students in the learning processes. In this paper, the main issues that have turned into barriers to the development of intercultural competences are summarized.

1. Language remains the first problematic issue confronting group work in an international context. The use of a second language (English) brings about lots of difficulties in both daily communication and professional discussion. However, different strategies have been developed to solve this problem when students get more familiar with each other.
2. Having different educational backgrounds, students hold different beliefs on learning. It is difficult for the majority of the foreign students, who come from learning environments in which they are guided by instructors who knows answers of all the assignment, to understand the concept of PBL. It demands time and experiences to understand the idea of learning with problem orientation and project organization, which means that nobody knows the exact answer until the project is finished, and students need take the responsibility to manage their own learning instead of only receiving instruction from authority passively.
3. It is difficult for many foreign students to understand that group work can be an efficient way of learning. In the Danish context, it is closely related to the social and political culture of democracy as well as the constructive approach in the belief of learning (for example, the creation of knowledge can come from everybody's participation and information sharing).

In some cultures where competition is highly encouraged and individual achievement is greatly valued in the assessment, group work does not have a cultural meaning to exist in the educational context. Due to these differences, many foreign students have different perceptions on the group-based assessment, compared with Danish students who are familiar with group work since primary school. When reflecting on their experiences of group-based exams (the report and oral defence), many foreign students had negative opinions: a) they (in the same group) made different efforts but got the same marks in the exam, b) they worked harder and did better job but got lower mark than other groups due to the subjective criteria in the assessment (differences among examiners), c) their individual achievement is not visible, and d) they could not see the benefit of learning if in their future workplace individual capabilities are more demanded.

4. Having different cultural backgrounds, students bring different social values, which can bring about miscommunication in the management of group projects. The main cultural differences are reflected in the behavioural patterns (what are good or bad manners), values on timing and efficiency (punctuality), ways of conducting meetings, handlings disagreement and reach agreement, perceptions on the role of teaching (authority vs. facilitation), attitudes towards learning (process-oriented vs. outcome-focused). Peer evaluation appeared to be much more difficult to be appreciated in a multicultural context than in the Danish group context.
5. There is a general lack of collaboration between Danish students and foreign students. In the case of UPM, on one hand, some Danish students changed their positive attitudes after the first project in international groups because they were disappointed that foreign students did not have as much expected knowledge as the Danish students did; therefore, they had to spend lots of energy teaching foreign students how to do things. On the other hand, foreign students felt that they had to adapt themselves to learn the Danish ways of doing things, because Danish students tend to take things for granted and teach foreign students how to do projects in the established ways that they have been used to. In this way, Danish students lose some chances to develop intercultural competencies when they are reluctant to work together with foreign students.

# Conclusions

To summarize the findings from these investigations, studying engineering at international master programs in the PBL environment, students are provided multiple learning resources to develop not only scientific knowledge, technical competences, but also process competencies like different social skills of communication and management. It is also a process whereby students develop intercultural competencies when this learning process takes place in an international context.

This paper argues that some concerns need to be taken into consideration in order to make the best benefit of international programs as an intercultural learning context. Firstly, in order to benefit students from different cultural and educational backgrounds, the facilitation of the PBL environment should not just be based on the established practices from the Danish programs.

In the establishment of international study programs, it is necessary to have a shared understanding of the concept of 'international', based on which, new values and practices can be established with the purpose of providing students learning opportunities to develop intercultural competencies as well as other capabilities. It is also necessary to bring about the general awareness that international programs can be beneficial learning contexts in which students from different cultures can learn from each other and develop intercultural competencies together.

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**Key words:** Intercultural competences, PBL environment, engineering education.

# PBL in a Multicultural Environment

## Experiences from a Master´s programme

Carsten Jahn Hansen and Xiangyun Du

# Abstract

Increasingly, it seems that problem-based learning (PBL) is regarded as a useful example of student centred learning and of dealing with the complex relationship between theoretical knowledge on the one hand and practical problems and issues on the other hand. Through more than three decades, Aalborg University has developed its own version of PBL, based in project work organised in groups of students. The result is a focus on the development of student abilities and competences related to discipline knowledge as well as to cooperation, communication, management and self-reflection. So far, the Aalborg version of PBL has mainly been implemented in settings of Danish students. However, in the last 10-15 years an increasing number of international students have joined Aalborg University. This has entailed new challenges to the Aalborg way of PBL; challenges associated with a move from a monocultural to a multicultural learning environment.

This presentation focus on the considerations, reflections and specific actions concerning the implementation of PBL in a specific and multicultural environment at Aalborg University, namely that of the Master´s programme in Urban Planning and Management. The presentation will be framed on re-establishing the chronology of events, material and products associated with the implementation in autumn 2005 of the first semester (term) of this programme. In particular, the presentation illustrates the challenges of establishing a common learning environment including both (Danish) students who are already familiar with PBL and international students who are mostly inexperienced with PBL.

# Introduction

For more than three decades Aalborg University (AAU) has developed and applied its own method of problem-based and student centred learning. The method emphasises the develop-

ment of student abilities and competences related to both discipline knowledge and the handling of complex working processes. Study programmes are mainly organised around problem- and project-oriented work in groups. This implies attention to interdisciplinary approaches as well as to cooperation, communication, management and self-reflection.

> *With this method a great part of the semester teaching and student work revolves around complex real-life problems that the students wonder about and try to find answers to in scientific manners while working together in groups. A recent evaluation from the Organisation for Economic Co-operation and Development (OECD) has shown that this form of teaching is close to optimal for the learning process. Through this work process and supported by courses, literature and the cooperation with companies and organizations, the students arrive at a deeper understanding of the subject investigated than what they normally would have learned from just reading and listening. Apart from the strictly professional outcome of this work method, it also brings the students other specific and important qualifications like e.g. good cooperation skills. (AAU main website, March 2006)*

However, this method has mainly grown in a context of Danish students. Through the last 10-15 years an increasing number of international students have joined AAU, thus entailing new challenges to the Aalborg way of PBL; challenges associated with a move from a monocultural to a multicultural learning environment. In addition, a number of new international study programmes have emerged at AAU, and the university officially profiles itself as being oriented towards internationalisation.

Hence, it seems relevant to ask how the Aalborg PBL method copes with these changes. How does the move towards internationalisation and increased cultural complexity influence the Aalborg PBL method? What challenges arise, and how can they be handled?

This paper and presentation aim to focus on and learn from the considerations, reflections and specific actions (and hence goals and means) concerning the implementation of PBL in a specific and multicultural environment at Aalborg University, namely that of the Master´s programme in Urban Planning and Management (see http://www.urban.aau.dk/). It is the intention to do so by re-establishing the chronology of events, material and products associated with the implementation in autumn 2005 of the first semester of this programme. The paper and presentation will conclude by tentatively suggesting some lessons for doing PBL in a multicultural environment.

# Preparing the semester

During 2004 and early 2005 it was decided by the study board responsible for the Master's programme in Urban Planning and Management (UPM) that the programme should become fully international, implying that all relevant programme material, courses and teaching material should be transformed into and carried out in English. The programme had started in a Danish version a couple of years earlier, however with the intention from the outset that the programme should change into English when marketing material etc. had been prepared. After having added the English version of UPM to the main university website, international students (with bachelor degrees) started to apply for the programme. Danish students also applied, mainly from the Plan & Environment and Geography bachelor programmes. As a result, 31 students were accepted into

the first semester (autumn 2005) of the revised UPM master's programme. A total of 12 nationalities (from 5 continents) were represented – 16 Danish students and 15 international students (7 guest students for one semester only + 8 students for the entire master's programme).

Apart from posing a challenge to courses and teaching material, this new mixture of students also posed a challenge to designing the teaching methods of the semester. In particular, the establishment of problem-based projects and student groups working with these projects were seen as a new challenge, given the significant differences in the background of the students. It was likely that Danish students would be keen to get started forming groups and projects. Having been through similar procedures for at least 6 semesters, it was reasonable to expect that Danish students would be interested in and able to establish groups and projects quite fast; perhaps in just a couple of hours. However, it also seemed fair to expect that most, if not all, international students would have no or rather limited experiences with PBL-learning in groups, and that the international students would feel left alone or without knowing what to do in the group and project formation process.

Hence, a new agenda and procedure for this process had to be established. Inspiration for dealing with PBL in a multicultural environment was sought in an associated Master's programme in Environmental Management (EM) at AAU. The EM programme had several years of experience in dealing with a mixture of Danish and international students. In particular, the EM programme had experimented with applying an introduction period, in which students were administratively put into multicultural groups in order to do a predefined pilot project. The idea of an introduction period was also considered useful for the UPM programme. However, the design was revised and changed somewhat.

The introduction period of UPM was reduced to two weeks only and without a prior establishment of groups or a pilot project. Assuming that all students would arrive with their own expectations and ideas for studying UPM, it was considered important to use this prior engagement to let the students themselves build ideas and settings for projects and groups. Furthermore, it was considered important to let the project and group formation aim at the entire semester period, meaning that the introduction period should avoid pilot projects and instead use the students own ideas to build the project and the group that would carry them to the end of the semester. The intention was to avoid discouraging the students unnecessarily by exposing them to a predefined pilot assignment that may not fit well with their initial and different motivations for joining UPM.

Based on experiences from the EM programme, the advantage of doing a pilot project in forced multicultural settings seemed to be that the students would accumulate experience with working problem-oriented in a multicultural group before building the projects and groups for the remaining part of the semester. However, in designing the UPM introduction period it was assumed that gaining sufficient (useful) experience with PBL in a multicultural environment would not come from a compressed and predefined pilot project only, but rather from one or two full semesters of group work.

Nevertheless, it was not without worries that the new design was established, and already before starting the semester it was planed that the working processes and its outcome should be monitored closely, e.g. through a steering group (semester coordinator student co-coordinator and stu-

dent representatives from each group), the compulsory semester evaluation (performed by the students) and a questionnaire (composed by the semester coordinator in cooperation with the students).

The presentation at the conference will discuss the preparations for the semester in further detail – including preparation of material and informing students, teachers and supervisors in order to prepare them for new roles and working processes.

# The introduction period

The first semester of the UPM master's programme was started on 1st September 2005. The introduction period was designed as follows:

- Introduction seminar: On the first day, the semester coordinator introduced the students to the entire master as well as to the semester. This included information concerning the programme in general, the contents of the first semester and some practical information. Most importantly, however, was to inform and discuss the general idea and design of the introduction period with the students themselves. In particular, it was emphasised that working across cultural differences might produce some very useful experiences and develop new competences. Finally, the process of forming ideas for projects was initiated.
- On the same evening, the students and some teachers attended a UPM welcome party.
- The following week, the students attended introductions to and lectures in several courses. Some courses where aimed at providing inspiration for the upcoming project work. Meanwhile, the students were encouraged to add, to the semester website, their own ideas, suggestions and proposals for projects.
- Halfway through the introduction period, a project café and LEA-seminar on learning in a multicultural environment was carried out. The project café focused on further building and discussing project ideas and topics, aided by a team of supervisors. As a result, the students and the coordinator agreed to end the process of establishing new ideas and topics by settling for a few well-discussed topics, but to continue the process of establishing groups based on these fixed topics in the following days. While the project café focused on the possible contents of projects, the following LEA-seminar focused on the process, in particular on the expected challenges as well as opportunities in working across cultural differences.
- In the second week of the introduction period, the students continued attending course activities, while discussing possible group settings. On the semester web-site, the students could add their own name to one or more of the fixed topics – in order to make visible their interests.
- A final project and group formation seminar was carried out by the end of the two week introduction period. As the topics for projects had already been settled, the seminar concentrated on the concluding establishment of student groups. The students worked hard on their own for two hours - resulting in the establishment of 7 groups; with only one group consisting only of Danish students.

The conference presentation will describe the introduction period in more detail, e.g. by providing examples of the material, the slides, and the methods used to get the students started.

# The rest of the semester

Having formed projects and groups, each group was appointed a supervisor with relevant experience or knowledge concerning the chosen topic for the project. The remaining part of the semester was designed so that course activities were most intensive in the beginning, with still more time for doing project work as the semester progressed. The final course activity took place in late November, leaving the students with a good month to finish their project. Halfway through the semester, a seminar discussed the status of the project work; based in student group presentations of each project and following discussions among all students and supervisors concerning how to proceed with the work.

Two additional seminars concerning PBL, learning in groups and professional communication were also carried out; one in late September and the other in late October. These two seminars aimed to aid the students in the processes associated with working in groups. In particular it was the intention to assist international students in understanding and handling the working processes that they were now becoming increasingly experienced with.

Through email correspondence and two meetings, the above mentioned steering group aimed to identify and deal with challenges or problems occurring along the progress of the semester. However, the main task of the steering group turned out to be to discuss and choose topics and candidates for guest lectures.

At the conference, the presentation will give more insight into the dynamics of the problem- and project-oriented work in groups, e.g. by providing a specific example.

# Evaluation of the semester

The semester has been evaluated in two ways: through a compulsory semester evaluation performed and written by the students, and a questionnaire initiated by the semester coordinator. The semester evaluation concluded the following (of special relevance to the issues in this paper and presentation):

- The introduction period for the group formation worked well, but there still were some problems on the final day where the groups were formed, however this properly can not be avoided because of the very different backgrounds and the normal problems in coordinating how the groups will structure themselves. Overall the group formation was a good process.
- The foreign students missed a more in dept explanation on how to do projects, witch could make it easier starting up projects.

- The LEA (Learning in a multicultural environment) seminars covered a broad aspect of problems, but the students would have liked to use more time on [individual] stereotypes. A discussion on how to do project/group work would be a good add-on. Only a few of the international students followed this course, therefore it is important for the next semester that it is amplified for all students the importance of this course. The semester coordinator underlined the importance of this course several times, unluckily without effect. An idea would be to hold all lectures in the first week.
- Some of the Danish students sees a lack of knowledge in computers, GIS, word and excel among some of the international students. This can cause problems in the project work. An idea is to use Danish students as tutors in an introduction course on how to use the above.

The questionnaire was answered by 19 out of 31 students. The questionnaire specifically encouraged the students to identify and describe their experiences with working in a multicultural environment. The answers support the remarks above, however in much more detail. Most students exemplified both problems and advantages in working in a multicultural environment. Interestingly, the problems described were mostly claimed to be related to individual differences, rather than to cultural differences. Many Danish students described their difficulties in teaching international group members how to do PBL and project work in groups, while on the other hand acknowledging the benefits from having expanded their worldview through the eyes of international students. However, most Danish students do not feel that such efforts are appreciated in the learning objectives of the study programmes. Most international students emphasised their difficulties in learning how to do project work in groups, but they also emphasised rather strongly that they have learned and benefited from having experienced those difficulties. For instance by becoming more open-minded and being pressed to defend ones own thoughts and ideas, and to use this situation to build common ground: `When group writing really worked, it was a unique and pleasant feeling´.

The conference presentation will present the evaluation and questionnaire in more detail.

# Lessons learned for PBL in a multicultural environment

The experiences with the new UPM programme illustrates some challenges of establishing a common learning environment including both (Danish) students who are already familiar with PBL and international students who are mostly inexperienced with PBL. Based on those experiences, the following lessons for PBL (in groups) in a multicultural environment are tentatively suggested:

- Use an introduction period in order to get new and international students started, but also in order to signal to local students that a revised version of the PBL methods well-known to them is about to be implemented. It is recommendable to take a starting point in the students own experiences and expectations, rather than to assign predefined tasks.
- The introduction period should be aimed at, and used for, letting the students discover, discuss and develop their mutual expectations as well as their interdependence.

- Include last year's experiences when introducing the semester, in particular concerning PBL working processes.
- Use the local students to actively integrate the international students, e.g. by tutoring arrangements or by letting the local students explain the local PBL style seen from their experience.
- Put (even) more focus on PBL working processes during the introduction period; in the UPM case by scheduling all LEA-seminars during this period, and by including more knowledge and discussion concerning individual stereotypes in these seminars.
- Individual differences seem to matter more than cultural differences. However, it is recommendable to avoid too many different cultures or nationalities in one group as it sometimes proves to be very time-consuming just to get the group to work socially – with negative consequences to the actual contents and quality of the project work.
- International study programmes should include learning objectives related to working process competences and to learning across differences and cultures. Thereby, the hard work of learning how to work in multicultural groups and settings can also be acknowledged and evaluated. This may also increase the motivation for the students to aim for more peer-learning across differences and cultures, e.g. to make a greater effort to make the groups work even better.

At the conference, these lessons will be explained further, and more lessons will be added and exemplified.

# A large scale problem based learning inter-European student satellite construction project

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Karl K. Laursen and Dan D. V. Bhanderi

# Abstract

This paper describes the pedagogical experiences and lessons learned obtained in a large international student experiment:

- Build and launch a satellite within two years time frame with students from a universities all over Europe.
- Develop your own cooperative structures.
- Students may be forced to obtain skills on the fly as needed.

From a teaching angle this can be viewed as a very complex Problem Based Learning (PBL) experiment.

ESA (European Space Agency) Education Office launched January 2004 this rather ambitious project: Let students from all over Europe build a micro satellite within 18 months from design to launch – today claimed as the the fastest satellite construction ever.

The project is in details described at http://sseti.gte.tuwien.ac.at/WSW4/express1.htm.

More than 150 students from more than 14 universities all over Europe were participating in the development and construction of the SSETI EXPRESS. The satellite was successfully launched on October 27th 2005 (http://www.express.space.aau.dk) and was in full operation the first 10 orbits until a power system failure occurred. We and ESA view the project as very successful. From the beginning not many did believe in it.

# AAU and PBL the starting point

Aalborg University (AAU) has a long tradition for Problem Based Learning at all three faculties since the birth of the University in 1974.

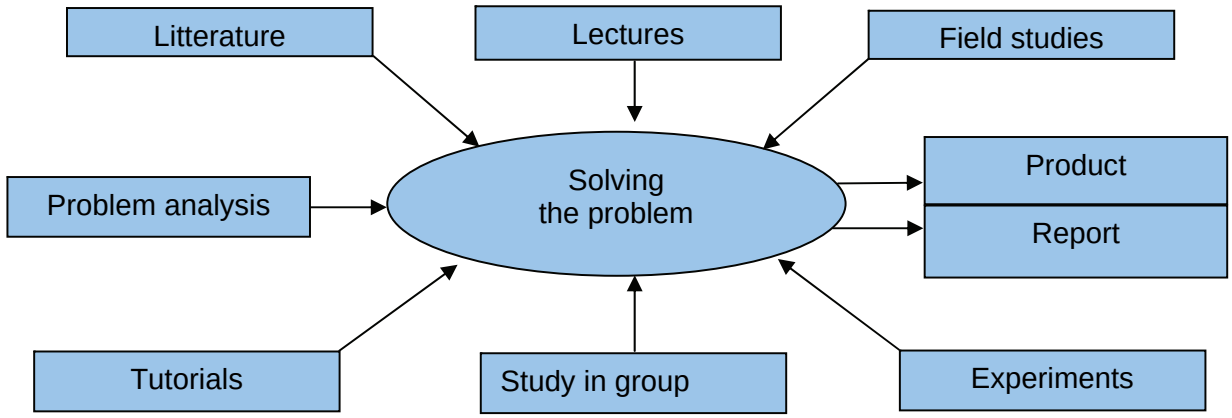
Within the engineering education skills are obtained by a combination of traditional lectures and group based project work with guidance and supervision from scientific staff.

The Problem Based Learning (PBL) paradigm is the cornerstone in education of engineers at Aalborg University. In fact, the entire educational structure of the university – at all three faculties - is based around project organized PBL. The students have an increased responsibility for their own learning – as individuals and to some extent on group level - by working in project groups. This requires the students to cooperate in carrying out the project work and communicate the curriculum between them. This teaching method yields higher level of reflection and deeper understanding [1,6] and at the same time learning to "work like an engineer". For a detailed description of the AAU implementation of the PBL model see [2, 3] or visit http://www.puc.aau.dk.

In general the PBL is implemented as follows: Students spend half of their (nominal) time working in groups focusing on solving a specific problem, and the other half on more traditional lectures. Each semester the students at own initiative form groups of typically 3-6 students. In the group they must select a project from a pool of proposals, which they will then work on during the semester under the supervision of a scientific staff member. Each of these groups get and a supervisor and an office of their own assigned for the project. All their study activities are carried out within the group. The students are supposed to be at campus 35-40 hours a week – like a "normal job" and in addition to that preparing for lectures. In this very close living the students are supposed to aide and support each other – and they do.

To ensure a certain education the project must fulfill some educational demands based on themes for the individual semesters. The specific problems, the groups work with in their project, can either be suggested by themselves, but most likely it is suggested by a scientific staff member, often in co-operation with industry. The students carry out the projects all the way from problem formulation and analysis, through the problem solving, and to the final result which is an 80-200 pages report and for the engineer students, a prototype of the system and technical documentation for what they have developed. The principle of the project work is shown in principle at figure 1.

Figure 1: A schematic over project activities.




At http://www.esn.aau.dk/english/UK_index/index_uk.html is our study structure for electronics and information technology at AAU – the homeland of the authors.

This organization of the education system has proven to be very rewarding for the graduates, and it is very popular with the students themselves, who prefer real life engineering problems compared to hypothetical, academic problems and lectures. This has lead to a highly beneficial cooperation with the local industry as many student projects are proposed by companies. Our students are examined within the same rule set as other Master Educations in Denmark. Our rating is as least as high as the others. 75% of the Master students graduate after 5.2 year(nominal M.Sc. study last 5 years) compared to 25% for a competing Danish educational site.

# Problem Based learning for building Student Satellite Programs

The typical engineering projects at AAU are structured for solving a specific problem within the duration of a single semester, and cooperation with other groups is seldom. The hardware built by the groups, and used for demonstration of concepts at the project examine, is at the prototyping level for “proof of concept” use, and seldom finalized to more than a functional prototype.

Building satellites is a massive extension of a standard one semester project.

It differs at least as follows:

- Duration more than one semester
- Cooperation between different groups
  - At different semesters
  - From different specializations (ex. electronics, IT, mech, communication,…)
- Not building a “proof of concept” but building a high quality spacecraft

- High level of
  - Documentation
  - Testing
- Putting the satellite in orbit
- Economy: 1 kg in low orbit cost US $40.000 just for launch

It is a requirement that a satellite is built and launched, which introduces a number of problems of implementing a satellite project within a PBL framework. A single group cannot be expected to design and build an entire satellite within one semester. It is necessary to involve several groups, from different semesters and institutes, for the duration of a number of semesters. Some groups are expected to be involved in only parts of the project, as tasks finalize or new tasks are proposed to new groups. Building of the satellite will take more time than justified by a normal student project.

This method requires extensive work in management of the projects, maintained jointly by the students and staff members.

A challenge for the scientific staff is to impose guidance on the project. In a normal PBL based project running a semester the rules are easily identified and the scope is rather limited.

The students are carrying out these normal semester projects under close supervision from their supervisor.

In contradiction the management and supervision roles of the scientific staff in the satellite project is reduced by purpose for fullfilling the intention that the students are in control of the project. The University staff (professors,…) conduct what we have defined as "*Invisible management and guidance*". The purpose is to be NOT in control of the project but be ready for guidance, supervision and in seldom cases more traditional management if the project comes in very deep trouble. This gives the students responsibility for *their* project.

The purpose is not to reduce the workload of staff but to let the students mature within the process. It is no secret that many frustrations – like different interpretation of workload or technical problems/challenges, … - can be very frustrating, but for the most the students reach solutions by themselves – as intended. A very valuable experience and learning.

# Satellite Structuring

A satellite is organized in a number of subsystems (like pro satellite development). Some of the main subsystems are: power supply, main control computer, payload, maneuvering, communication and ground station. To hav a functional and efficient management each subsystem group appoints a delegate – a system engineer – which participates in the steering committee. A second seat in the committee is given to each group, occupied round-robin amongst the remaining group members.

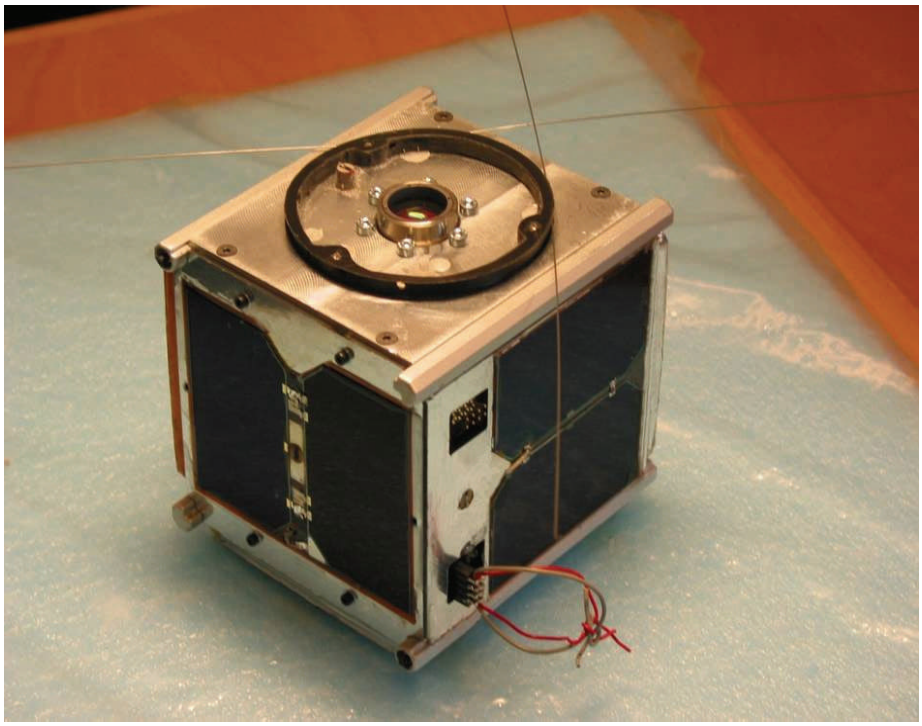
This ensures consistency and continuity in the steering committee and ensures that all students are included in the management tasks, whilst limiting the number of people present at meetings.

At AAU, this structure is mainly implemented in the first half of the project, since experience shows that the number of groups involved, and also the sizes of the groups, tend to decrease over the project period. This is due to the fact that tasks at the finalization of a satellite, i.e. implementation, integration, and testing, are not tasks which semester projects can be based on within the curriculum. Hence these tasks are typically done by students in their spare time, motivated by the prospect of launching the satellite into space. From an educator's point of view, this is an important benefit of PBL in space education, as the extra work put in by the students, also gives the students relevant hands-on experience, without compromising the scope of the curriculums.

The steering committee ensures the maintenance of necessary system engineering documents, such as user and system requirement documents, time plans, milestones, etc. In the beginning of a satellite project, the main part of these tasks is handled by staff. As the project progresses, the maintenance responsibility of the documents are passed on to individual students in the steering committee. This is done to prevent work overload of the students at the beginning of the project, since project management is a comprehensive task, and the students have courses to follow, and sub-systems to design on top of this work.

Students at AAU did succeed to build their first satellite in the period 2001-2003 which is shown in figure 2. The satellite was in orbit June 2003 and was in successful operation for several months (http://www.cubesat.aau.dk)

Figure 2: AAUs first CUBESAT  10cm x 10cm x 10 cm 1 kg.



# PBL and building an international student satellite ESA's SSETI EXPRESS.

European Space Agency (ESA) has an obligation to spread interest and knowledge for space. For that purpose ESA Education Office has several activities ranging from public schools to university students. Activities range from visit from school children to building student satellites.

Compared to normal PBL education activities SSETI EXPRESS may be regarded as a very extreme high risk project in context of the project and the variety of students involved. Such a large scale "experiment" has not being tried before.

The project was a student driven project with student project responsibility adding at lot of international experiences and project management skills to the outcome of more traditional one semester, single group projects. The ESA Educational Office associated a technical coordinator and an administrative coordinator with the project – two very important anchor persons.

ESA Education was formal in charge of the project and individual students NOT universities were enrolled as participants. More than 150 students from 14 universities were participating in the whole project period or parts hereof. The main idea of enrolling students instead of universities was to let the student be in control and not the universities.

Some of ESA's criteria's of success was:

- Get engineering students interested in space.
- Get engineering students all over Europe to meet and cooperate.
- Having cooperation despite peoples different physical location.
- Have a design of a satellite to be developed.
- Get a working model.
- Get a flight model build (the one to go in space).
- Get a satellite up in orbit.
- Operate satellite from earth.
- Get attention from children, students and population in general.
- Get it all done in a time frame of 18 month.

It is interesting to observe that success was not only a matter of flying a satellite but mainly to gain attention for space and space education, and to have students cooperate over the borderlines in Europe. Participation in a successful large scale inter cultural problem based engineering project includes a variety of engineering disciplines as mechanical construction, communication system, power supply, attitude control system, onboard computer systems, software, ground station and payloads, all to be covered by students from universities using different educational models. In addition due to the number of involved partners, economics and physical distances many of the students never meet in real life, implying that cyberspace communication technology was vital within the project.

The combination of the PBL educational system and the satellite experiences within the Department of Control Engineering made it very relevant for our students to participate in the ESA student satellite SSETI EXPRESS. Our year long experience in PBL and the very non formal way “Scandinavian” of real cooperation between students and teachers/professors provides the students with the necessary skills for such a cooperation.

# The effect of PBL trained students in an international project

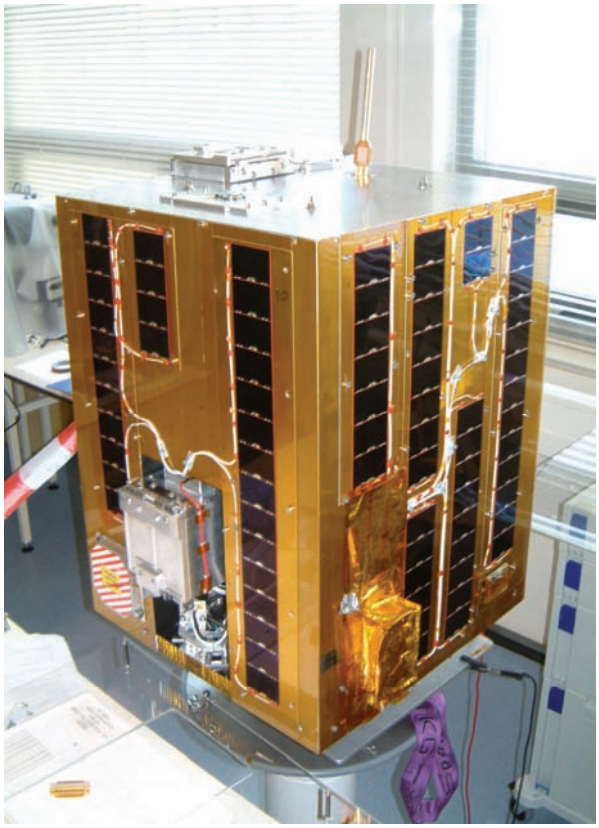
From the beginning the AAU students were responsible for one of the subsystems, the attitude control system. The AAU student involvement changed very much during the project. This did change very much over time. For a number of the participating students from around Europe it seems to be very difficult to do this very complex project work and project cooperation. For many of them SSETI EXPRESS was their first project ever. Many engineer education institutions around Europe still stick to a traditional academic method of learning – mostly based on lectures and exercises.

In contradiction to that the students from AAU had very high benefit of their PBL skills. They were able to obtain an overview of the whole project. From being responsible for only a minor part of the satellite they did overtake work and subsystems from other students which realized they could not perform within the very limited time frame. They ended up as a major player in system management and system integration, they delivered four subsystems including the main computer and the communication system and finally they developed two ground stations, one at Aalborg University and one remote controlled ground station at Svaldbard in the North Atlantic. The launch operations were conducted at the local "Houston" Ground station in Aalborg.

A number of problems were identified:

- Many universities did not have any tradition for PBL or doing project work as part of the study – e. g. the students was not familiar with working like real engineers.
- Many universities did not try to incorporate the students participation in the curriculum.
- There are very broad span in cultural behavior across Europe. But all students were trying to perform to their best.
- It didn’t fit to a standard semester - 18 months for the satellite project compared to 5/6 months for a “normal” semester project.
- Difficulties in integrating the tasks in the education at the traditional universities.
- The complexity in the satellite project is extreme compared to a standard PBL projects.
- The project had to end up with a real tested product at the launch date!
- The last phase: finalization and launch campaign is very difficult to fit into the study curriculum.

Figure 3: SSETI EXPRESS flight model



# Effort Distribution

A normal student project has a distribution in the workload roughly as follows:

- Obtaining knowledge 15%
- Problem Analysis 25%
- Problem definition 10%
- Design 30%
- Implementation and test 20%

The construction of a satellite is more like:

- Obtaining knowledge 10%
- Problem Analysis 10%
- Problem definition 10%
- Design 15%
- Implementation and test 55%

This does imply that the students use less time of the first bullets but rather that much more working power is put into the project.

This can have some curriculum problems if all the time used by the students has to be part of their education. In real life they use much of the private time, holidays etc.

# Lessons learned

It is our honest believe that engineering students which are following a PBL project based study has skills not obtained at more traditional engineering education institutions. It is natural for them to work as/like an engineer. Their capabilities within project organization and structural analysis etc give them many advantages in a complex project like SSETI EXPRESS. It has also been interesting to observe that the other students recognize these qualities and give them space in management as well as at technical level.

A negative side effect has been that our students has been among the most engaged and hardest working at the project. This may have an impact on their “normal education”. But the university has seen this as an alternative and very promising way of obtaining curriculum. This is also a necessity if we as responsible teachers shall “let” our students participate in such projects.

From a student perspective this is the ultimate way of learning to be an engineer. The price is the time used – which can be many hours.

In that context it can be argued that for many of the participating students such a project becomes a mixture between education and a hobby.

After the launch the project has been acknowledged from ESA top leadership as a very high quality project, which has paved the road for continuation of such projects in ESA regi.

We are already on way with the next AAU student satellite AAUSAT:
See http://www.aausatii.aau.dk

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# Integrating Industry in Project Organized Problem Based Learning for Engineering Educations

Kirsten Mølgaard Nielsen


# Abstract

This paper deals with the challenge of establishing engineering student projects in collaboration with industry. Based on empirical results a set of advices for industrial collaboration in project oriented problem based learning are formulated.


# Introduction

Project organized Problem Based Learning (PBL) has been an integrated part of the engineering educations at Aalborg University since the University was established in 1974. The project work generally accounts for 50% of the study time. Other 50% is conducted in the forms of lectures, courses, seminars, classroom training, laboratory work and workshops.

At Aalborg University important aspects in engineering education are learning objectives, achieving deeper and more lasting understanding of theory, integration of curriculum elements and outreach objectives involving universities, industry and the public at large. In addition elements as development of communication skills, design skills, team skills and sensitivity to social, environmental and economic factors are important. The team end project based PBL model support these demands.

The idealized problem based learning project work deals with real life problems and most engineering students are highly motivated by projects carried out in collaboration with industrial partners. This paper deals with the challenges of establishing and performing industrial student projects in which the students need to use the theoretical disciplines from the semester curriculum in progress in solving the project problems.

At the same time the collaboration has to be established as a win - win situation to industry and students to secure the possibilities of analogous future projects.

The project work is defined within a semester theme, describing the disciplines to be included. It is supervisor responsibility to ensure the projects include all relevant aspects. The theme description always has to be taken into account when formulating industrial collaboration projects.

At the first semesters the study plans are relatively tighten. All the students have to do project work based on basic theoretical disciplines. As it is difficult to find industrial projects fulfilling these demands most student projects tends to be university formulated laboratory projects using dedicated equipment to illustrate the theories in focus. At the higher semesters there are less specific study plans giving better possibilities for establishing relevant industrial projects. Additionally the students have an extended knowledge at the last semesters.

# Motivating factors

Initially all partners in industrial student projects are positive to the idea. Having different goals for the collaboration it is still possible to establish student projects as win – win – win projects to university, students and industry.

## Universities

These years there are an intensive political focus on the usability of university activities to the society and especially to the industry implying that it is of particular interest to the university to establish industrial collaboration at all levels of research and education.

Industrial tasks are seen as an important motivating factor and a great challenge in student projects by most staff members. At the same time it is interpreted as a way to establish contact to industrial partners giving the possibility of future research collaboration. Establishment of research collaboration projects involving a large amount of manpower and financial support can be difficult as a first co-operation. Especially projects involving the university and small companies unused to that kind of projects can benefit from student projects.

## Students

Students are very motivated by projects based on real life problems. In addition to the “normal” benefit from project work, the industrial collaboration will give a possibility to take part in solving realistic problems, a deeper knowledge on conditions of employment in industry, typical real-life projects, communication skills, team work and maybe even a part time student job or a job for the vacations.

# Industry

The motivations for industrial companies to participate in the formulation and implementation of student projects are differing. Some companies set up project proposals for patriotic reasons. Another reason is that there has been a growing lack of engineers in Denmark and Western Europe during the last decade, implying that companies are motivated to help attracting students to engineering universities and especially to motivate students to specialize in disciplines useful for their own companies. One of the ways to realize this is collaboration with universities, especially to formulate and assist in running student projects.

To obtain a fruitful collaboration between students and industry it is very important to clarify the collaboration conditions to the students and the company and to agree on the expectations. In this paper experiences from very successful as well as less successful collaboration projects are used to set up a generalized list with elements to be taken into account for collaboration projects. Important examples are mentioned below.

# Project examples

In the following section examples illustrating different types of collaboration project necessitating different types of agreements are described.

The examples are taken from the control engineering educations. Control engineering is applied in a wide range of applications as consumer electronics e.g. CD-players, in power systems, in plant automation, in motors and pumps etc.

Within the control engineering educations at Aalborg University there is a well established tradition for definition of student projects in collaboration with industrial companies. This type of projects always demands knowledge of the structure of the system in focus as well as of the dynamic behaviour of the system, making real time system data essential to all projects. Data can be the first hurtle. First it can be very important and sensitive to the production while the company might wish it confidential. Secondly it can be difficult to get even though it can be obtained in several ways, either by data acquisition on location or remote data acquisition, by installing a system or a system model in the laboratory or by real time simulation.

Correspondingly it has to be possible to activate the system through actuators.

A Danish food production plant is technically very complex and holds many very interesting tasks from a control point of view. At the same time the company is very co-operative. To be useful for student projects some practical problems has to be solved. The geographic location of the plant imply a 5 hour travelling time each way and due to the growing season the production is only three months a year ( October, November and December). The autumn semester at the university is from September 1st until end of January, and the spring semester is from February 1st to the end of June, meaning that it is impossible to get new measurements in the spring semester as there is no production. In the autumn semester all data collections and changes have to be well planed at a very early stage, as the plant staff is very busy during the production period. The first student projects ended up chaotic as all data had to be reconstructed from old plant supervision information.

To overcome these problems the supervisors and the factory staff had to get a good overview and a long term plan. Possible student projects was planed by university staff and factory staff at least a year in advance to secure the necessary data collections in advance. Additionally a real time simulator illustrating the dynamic behaviour of the relevant parts of the plant was developed. To give the students on-location knowledge and the possibility of discussion with plant staff the company was willing to pay the student travel expenses. Taking these initiatives into account the production plant was well suited for student projects during several semesters in the automation education.

Small upcoming companies often rely on a very specific idea. A major area of concern is to loose the idea to competing manufacturer. In many cases the company expertise is not covering all aspects of the product or production and they need solutions within a short period. What they really need is consultancy work as cheap as possible. In such cases it is very important to make it clear that student projects don't guarantee a result and doesn't comprise product maturing.

An example is an upcoming communication company. The formulated project involved equipment very important to future success for the company implying strict confidential requirements.

To run this project, it had to be made clear to the company that the university basically is an open environment. In this case it turned up to be a problem as it was relevant and convenient to place company equipment at the university. Laboratories are not public, but many students and staff have access. The solution was to place the equipment in a locked laboratory, making it clear that it couldn't be guaranteed that anybody from outside would get access. Another problem was the students' final report. It is basically public, but it is possible to make parts of a report confidential. The students were asked to sign a declaration of confidentiality, but the university strongly advised them not to sign a competition clause.

Some of the very large Danish industrial companies have learned how to handle student projects. They are formulating a wide range of projects. Most of them are very easy to handle. The projects are formulated to fit into the study plans, the companies support with necessary equipment and data. Additionally they let the students visit the production plants and make staff disposal when necessary. The purpose for these projects can be to develop and test ideas and principles for future use making the company independent of short term results.

According to the above mentioned circumstances it could appear to be very problematic to establish good and successful student projects in collaboration with industrial partners. That is not the case. The examples illustrate problems in the establishment of the first collaboration projects. Later some general considerations has been taken into account and every case ended up with very successful projects. One of the lessons learned is, that it is very important that the supervisor carefully evaluate the project ideas before startup.

These examples illustrate different types of industrial student projects giving different advantages and disadvantages. Empirical results from the examples and other projects show that industrial involvement in student projects in general are very positive but it need to be well planed and arranged to be successful. In the next section some of the issues are enhanced.

# Guidelines for development of industrial projects

When the university was established 30 years ago the staff had to do a lot of field work to find relevant industrial projects, IPR almost always accrued to the company. Now it is the opposite way round. The companies turn to the university and they pay parts of the expenses. IPR is shared between the company, the students and maybe the supervisor. Still the supervisors have to evaluate the proposals carefully due to the possible use of the theoretical disciplines in the semester theme, the availability of necessary equipment, information etc.

In this section identified rules of thumb for god collaboration projects are pinpointed.

## Student project definition

The first thing to handle is defining a student project to the company and the students. It is important to clarify the expectations to the partners. It has to be made clear to the companies that student projects are different from consultant engineers. Student’s projects have to fulfill the study program; the project reports in general are public and as a minimum it has to be read by a censor. Given some of the data are confidential it is possible to split the report in two parts a public part and a confidential part.The curriculum describes demands for the disciplines to be handled which is more important than company relevant results.

In the best case the company can benefit from investigation of solutions to long term tasks within the company or from the solutions as a kind of prototyping. Projects can't be used for final product development.

Even though the companies have to spend time and maybe money and equipment student projects don't necessarily lead to a solution to a present problem. Though given the company has staff acting as sparring partners it can benefit from student attention and knowledge of the company, future engineers with specialisations within the area of the company and easy aces to university staff for instance for research results and advices to company problems.

A subsequent problem could be that new ideas as well as facts on efficiency and similar matters must be released if relevant to the agreed project.

Another important issue is to make a realistic estimate on the performance level of the company– preferably a timing of necessary assistance.

Companies have to realize that participating can be an extra strain to busy staff. During a project period the company has to be supportive due to competent staff – not necessarily engineers, plant operators with a detailed knowledge of the production are also relevant. In a similar way it has to be clear to the students that confidence and respect to working conditions and production within the companies are very important. Data acquisitions and tests must be planed and pre-agreed with company staff in detail. At the same time the students have to be aware of that deals tends to be broken in busy periods in the company.

Student projects are not a consultancy assignment giving a guarantied solution. In student projects students supported by a supervisor are working at the tasks for a semester; there are no guarantees for the result but always the advantage of outside ideas to the solution of relevant tasks. Usually the student commitment and result is related to the company commitment.

The project proposal needs to be well prepared before the semester start-up which can be a time consuming process. It is necessary to inform the company that even though the project proposals are well planed it is not necessarily chosen by the students.

# Economical aspects

Other important issues are to make an agreement on all economical aspects of the project and to make an agreement on legal property rights IPR.

Concerning direct costs, it must be made very clear to the company that participating involve expenses. Staff has to participate in project meetings; most engineering projects necessitate aces to data and equipment and an agreement on the responsibility for equipment to be operational is needed.

In general the data will need to illustrate the dynamic behavior of the system. It has to be realized that such measurements can be difficult and expensive to obtain and sometimes it can catch out company secrets. There is a big difference in the usability of on-line and off-line data measurements; the students must know what will be available. Data can be directly accessible, but in many cases it is necessary to disturb a steady state stability to gain information on system dynamics. In sensitive plants this type of intervention is undesirable.

Given data acquisition and tests are performed in the plant a project often requires equipment added in the plant. Alternatives are to build a physical model in the university laboratory or to develop a real time simulator illustrating the dynamic behaviour of the plant. In general the university will not be paying for equipment to be placed permanently in a plant. Equipment can be lent out from company to university or visa versa. A typical solution is that companies are paying for data acquisition equipment, parts produced by the company and sometimes for physical models.

The geographic location can be another hurdle, but can be handled by payment of travel expenses.

# IPR

Legal property rights (IPR) are an important issue in most collaboration projects. Given the invention is part of a product the company often are interested in protection for further development. The patents are taken out mainly to prevent rival companies in blocking further development. IPR can be shared. One way to handle it is to give the IPR for applications related to the specific plant or production to the company and the rights for the methods used in other application areas to the students and the university.

In projects resulting in new products the IPR typically are shared between the company, the students, the supervisor and the university.

## Benefits from industrial student projects

University contact gives companies the possibility of research related projects. The students and staff will gather knowledge on the company and related problems can be incorporated in the curriculum. At the same time it will help in attracting people to the area.

Real life problems motivate students to work harder, sometimes they use al the spare time doing project work. The project can be launch pad for future collaboration and the students get grounding in the business basics. Another possibility for students to obtain industrial experience could be work experiences programs. In these programs the primary problem is to ensure that the student get relevant experiences and not is used as cheap labour whereas project work ensure the relevance to the student.

# Summary

This paper has illustrated some of the issues to be taken into account to obtain successful student projects in collaboration with industrial companies.

The results are based on empirical results from a wide range of student projects. Selected examples are used to illustrate some typical characteristics of these projects.

The most important issues to be handled in advance is legal property rights, student aces to data and equipment, financing of additional equipment, travel expenses etc.

Taking all these issues into account industrial related projects is very successful in the area of student motivation, student commitment, students' industrial experience and university relation to industry at all levels.

# Crossing the borders using Problem Based Learning

## A challenge for the communities of practice in company based development

Lise Busk Kofoed and Frances Jørgensen

# Abstract

This paper discusses establishing Problem Based Learning (PBL) processes within the context of a longitudinal study utilizing exploratory case study and action research methods in a mid-sized Danish processing company where the challenge is to be 'a learning company'. The methodology and theoretical basis for the workshops for employees and managers dealing with PBL is described. The problems connected to the challenge of sharing knowledge and experience with other teams and departments in the company are solved during the work with a PBL project. Finally, it is suggested that the core principles of developing and implementing PBL processes can play a valuable dual role in the developmental process by supporting both radical development for the company and learning processes for the employees, and initiating new learning processes.

# Introduction

Learning and development in today's workplace has become more of the norm than the exception.

The objective of this paper is to describe and analyse a case in a company wishing to establish 'a learning organization' and support the employees in changing their culture from just doing what to be told to acting independently, analysing problems and finding acceptable solutions. The aim of the company was for the employees to perceive themselves as an organization of teams working within a team as well as across teams, so they would be able to use and share knowledge and experience across the whole organization.

Furthermore learning and development should be part of the daily working life.

The Case is a company within the processing industry with approximately 350 employees and a rather big turnover, and half of the employees worked with production activities on a three-shift basis. The shifts had been very engaged in teambuilding activities to perform as the best shift and were in reality communities of practice (Wenger 2002) which in many ways is a good and supportive strength for learning processes for the individual shift member. The shift members developed knowledge, shared experiences within the team, and had a very strong team identity. Each shift considered itself the best and there was a strong tendency to compete against the other shifts. They performed legitimate peripheral participation (Lave & Wenger 1984) e.g. during training of new shift members which took place within the shift. The shifts lived in a way their own isolated life and felt they could not get any support from the other shifts or departments in the company. A major problem was that they held all new knowledge and experience within the shift, out of fear of not being the best shift. Thus, there was no exchange of knowledge among the shifts. Furthermore, it was very difficult for the shifts to cross the boarder to other departments when they had to ask questions to get information or to solve problems which included a common understanding of the situation. So the company was characterized by isolated shifts/teams and very little communication and understanding among the different departments. This was not at all a beneficial situation for establishing 'a learning organization'.

To address these problems, a research group started a longitudinal action research project aimed at giving the employees an understanding of the importance of sharing knowledge and experience between the shifts and the related departments, and at the same time focus on the development of learning and problem solving skills. Based on workshops which had a PBL approach, the aim was that the shifts and the connected departments should end up with an understanding of their own learning process, how they could develop new knowledge in groups/teams and share knowledge with other shifts, an understanding of own role as part of a learning organization, and a plan for developing different ways of crossing the boarder e.g. get contact and understanding of departments with which they have to cooperate.

# Empirical Background

The research project was conducted during a period of five years in a mid-sized Danish processing company, which is a division of an international concern. There was a very distinct division existed between the employees in the production com-pared to those performing the administrative and management functions within the company.

Due to many factors, the company had suffered the loss of its competitive edge and faced mandates to improve efficiency and effectiveness on all facets of its operations. The company culture is focused primarily on control and safety and there are numerous fixed rules and procedures connected to the work processes, especially those in the production area. Further, the culture rewards reliability and "doing what you are told to do". Most of the shift workers have worked more than 15 years in the company, and they are strongly socialized within their shifts to obey the culture. Each shift had own subculture within the organizational culture.

One of the problems was that they would not exchange experience or new knowledge among the shifts; they saw their connected departments as enemies who did not understand their situation as well as they had no understanding of other department's situation or their common dependence.

The question was how to establish an understanding of the organization as a whole or as a team of teams, where sharing of knowledge and experience would be of vital importance. How could we design learning processes within the culture, without ruining the positive situation related to communities of practice (Lave & Wenger 2002), and also attempt to break through the borders of the communities?

# The Methods and Learning Theory Used in Workshops

The research team designed workshops for all teams: shifts and departments. All workshops are based on Kolb's experiential learning cycle (Kolb 1984), Schön's experiments (Schön 1987) and the Problem Based Learning approach (Busk Kofoed et al. 2001), with emphasis on meta- learning processes, and Stacey's ( Stacy 2003) shared visions and common mental models.

The concept of the workshops is to create a learning situation in which participants have the opportunity to develop, experiment with, and evaluate new ideas or solve problems associ-ated with their daily work activities. A precondition to the learning experience is that partici-pants feel secure within the learning arena. For this reason, it should be stated clearly that "mis-takes" are not only allowed – but even expected – as potential solutions to work related problems are tested in a simulated work environment. Participants in the workshops should also be encouraged to view themselves and their co-workers as experts, each possessing unique ideas, talents, and skills, which can positively influence the learning in the workshop and the developing process. The workshop which was also named the experimentarium is inspired from and built on the ideas used in other peda-gogical instances within the participative-socio-technical tradition (Rosenbock, 1980; Ehn, 1988 and 1992; Corbett et al. 1991 and for further description, see Busk Kofoed et al. 2000). This approach focuses on developing learning processes with participants assuming responsibility and ownership for their learning and the projects on which they will work in the workshop. At the same time, we chose to include aspects of specific competence development into the learning process, because we view this development as an important part of taking responsibility not only for the daily work processes but also for initiating possible improvements.

Because it is critical for participants to assume responsibility for their own learning process and also that learning occurs in the context of real work issues, the participants themselves must select existing problems from their work environment for which they will learn through analysis and formulation of potential solutions. By centering the project exercises around their normal work functions, the participating teams also gain experience in such areas as communication and problem-solving without fear of negative consequences on their productivity (DeGeus, 1997).

The chosen project can e.g. deal with developing a new work method, which participants wish to explore further together and possibly find solutions, which accommodate aspects of an improved performance. This approach is based on project work and problem-based learning (Kolmos 1996).

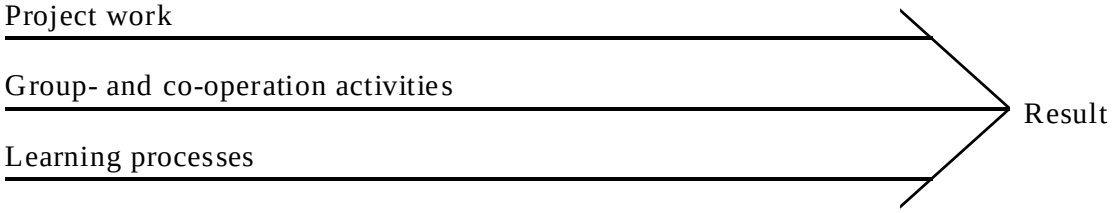
To increase the likelihood of successful learning within the workshop, a specific peda-gogical approach and method was followed. The theoretical approach is taken from Schön's theories about the reflective learner, combined with Kolb's learning cycle (Kolb 1984) which in the interpretation of Cowan (1998) consists of four phases: 1) experience, 2) reflection, 3) gener-alization, and 4) test. Guided, pre-planned reflections have to support the learning process. Cowan considers the reflection as the central issue in the learning process, which is why he also describes his learning concept as "reflective learning" (Cowan, 1998). Schön (1978) distin-guishes between reflection related to action and reflection related to experience, described as reflection-in-action and reflection-on-action. These types of reflection are mostly retrospective in their attempt to analyze actions for the purpose of using the gained experience and the deducted theories in future learning situations. Cowan ads a third learning distinction, reflection-for-action which is a reflection typically made before starting a project. Our learning approach, based on Schön, Kolb, and Cowan, thus, encompasses 3 pre-planned reflection loops:

Reflection – for – action
Reflection – in – action
Reflection – on - action

The workshops in this study are based on a model in which the following three processes operate concurrently (see figure 1.):

- Project work: Group identification of a work related problem to serve as the focus for a project (problem based project).
- Group work: Participants actively working together as a group (group organized project work).
- The learning process: Learning processes with awareness of the meta-learning which supports development of individual and group problem-solving skills (learning how to learn), and a strong focus on pre-planned reflections.

Figure 1 illustrates the 3 parallel tracks which are dealt with in the workshops. The learning processes are facilitated by 3 planned reflections (loops).



The design and context of the workshops are very context dependent and all aspects of the organizational environment, including the company culture, political processes, and man-agement style will largely dictate the possibilities available for the workshops.

One significant way in which the environmental conditions will affect the learning process concerns the practical arrangements of the workshop.

Such factors as the resources the organiza-tion can allocate to the activities in terms of time for meetings, space for the participants to meet, and the duration of time in which the workshop will be permitted will all have a bearing on the course of the workshop.

# The Process and Outcome of the Workshops

Participants in the different workshops formed groups and worked with a specific problem that they chose by themselves according to some given themes related to their work situation. Each project period consisted of 3 full workshop days where participants were introduced to the pedagogical model: how to work in a group, how to organize a project, how to choose a problem, how to analyse a problem, and how to find and test solutions. And finally participants learned how to evaluate and present their solutions. The workshop was a mixture of lecturing, exercises and work with the projects. During the project period the groups got supervision. Each group had 2 – 3 meetings with a supervisor from the research group, and they were allowed to contact the supervisor and ask questions via mail or phone. For supervisor meetings the groups had reflected on the progress of their project and possible problems they wanted to discuss. Furthermore they also reflected the cooperation in the group as well as their learning process. The last subject was rather difficult until the research group developed a game about the theoretical learning aspect based on the Kolb learning cycle. (For further description se Busk Kofoed & Rosenørn 2003).

Most of the groups made a rather good project, and some of them were implemented immediately. So the PBL – learning experience could be seen as a success. Some groups even made a project about a plan for knowledge exchange between the shifts and between the shifts and the laboratory.

But still there was a major problem: The lack of communication between the departments and understanding of each department's problems. So the research group decided to make a special workshop with the aim to cross the boarders.

This special action started with a workshop for representatives from each department, and they should make a 'reflection for action' working with the following problems: Where are the borders to other departments? Which departments do we have to be in close contact with? What important information and knowledge are needed from the different departments so they understand our need and we understand their need? What do each department expect from the other department and what are the departments able to deliver according the common goals?

This ‘reflection for action’ was an eye-opener for all participants. They suddenly recognised why it sometimes was problematic e.g. to get some test results very fast from one department.

Another department also found that they had to be much more specific when they asked for information if it should be useful for the planning task. And one department realized that they did not know which support they actually could get from the IT- department.

After this special workshop each department started formulating a project to solve one or some of the problems. They did their project work according to the previous learned PBL method, and quite fast they had solutions to be tested and implemented in their daily work. It was projects about an improved planning system for the production process and the planning department, projects about how to share knowledge and information between 3 departments etc. One project was about efficiency at the laboratory which had always got complaints because all departments wanted their test to be prioritised 1A. When different departments worked together on a solution for the laboratory they developed a priority system and recommended that an extra laboratory assistant was absolutely necessary. The management agreed with all the projects, and they were all implemented.

# Conclusion

In this paper, it is shown that establishing learning processes based on the PBL approach can lead to rather successfully results regarding the concrete outcome as an improved performance, but also the outcome as the employees and management’s awareness of learning processes and the reflection needed for the employees to develop a new understanding of the importance of sharing their valuable knowledge and experience with other teams and departments. In addition, the process by which the workshops helped facilitate knowledge creation about how to share knowledge was outlined. And during the workshops, the participants recognised that keeping knowledge within the team or the department only could be detrimental for the other departments. Furthermore it became clear that lack of knowledge about other teams or department could create a very poor performance for both.

The employees became aware of the negative chain effect from lack of knowledge sharing. They explained the problem to management, stating that they would like to work with a project so they could find a way to share knowledge and experience with the purpose of functioning better. In this process, the borders were very clear, but the teams were able to cross them as they continued to work as teams or departments during the period of the new project. Establishing the meta-learning processes gave the employees new identity and self-assurance. They became proud of being able to create knowledge that was important for other departments and the whole organization. And this supported their existing identity and at the same time helped them to add a new understanding of an extended identity as being part of a team of teams.

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**Key Words:** Problem Based Learning, Change processes, Knowledge Sharing, Communities of Practice.

# Assessment of Problem based, Project Organized work as performed at Aalborg University

Torben Rosenørn

# Introduction

## Assessment of students' learning at universities

Assessment is a topic which is highly debated particularly the assessment of PBL based learning and of project organized problem based learning. The discussion further comprises assessment of new competencies like communication skills and social competence which is today a part of the general scope of many university education not least the engineering educations. For this it is necessary to assess cognitive as well as affective learning.

We also claim that this must be done in a fair way showing the actual level of the individual student. The results of the assessment are used for comparing universities through benchmarking and are used for:

- Proof of the student's learning level within a well defined area.
- Document that the student has acquired the competences demanded by the labour market.
- Document that the student has acquired the qualifications demanded by the authorities (the state).
- Be a part of the university's quality development and quality control.
- Contribute to the student's motivation and self recognition.

*(Hansen, I.L & Rosenorn, T., 2005)*

All above very important topics which require accurate true information.

Research done by Arne Jakobsen at the Danish Technical University shows that investigating the marks given to students based on a 4 hour written exam show no clear correlation between high marks and the students' comprehension level for the topic in question, whereas there was a very good correlation between low marks and a low level of comprehension.

(Jakobsen, A. et al. 1998). Only half of the students who got high marks had a deeper comprehension of the topic, however, they mastered the other types of assignments given at the exam. Findings showing a similar tendency have been described by James N. Spencer (1999).

# Just assessment

Donald R. Woods et al., (2002) describes assessment in an article in Chemical Engineering Education as: "a judgement based on the degree to which goals have been achieved using measurable criteria and pertinent data". This statement is operationalized through the following five basic principles:

1. Assessment is a judgement based on performance, not personalities.
2. Assessment is a judgement based on evidence, not feelings.
3. Assessment should be done for clearly identified purpose and with clearly identified performance conditions.
4. Assessment is a judgement done in context of published goals, measurable criteria, and pertinent, agreed upon forms of evidence.
5. Assessment should be based on multidimensional evidence.

This sounds reasonable for assessment of cognitive learning, but may not be realistic when the affective learning and personal and social competences are part of what is to be assessed.

# The Aalborg Model

The foundation of the Aalborg Model is built over three key elements:

- Study unit courses, which are approximately 25% of the students' workload during the first 8 semesters.
- Project supporting courses, which are approximately 25% of the students' workload during the first 8 semesters.
- Projects (one each semester) which is approximately 50% of the students' workload during the first 8 semesters.

In semester 9 the project is usually more comprehensive and is almost 100 % of the work load and semester 10 the project is 100% of the work load.

The project must provide students' with structure in the disciplines that have been decided on for the project. Additionally, competences in working in an analytical way, in collaboration, in oral and written communication, graphic presentation, in planning and carrying through big projects, and in being able to work using various scientific methods must be developed.

The courses are aimed at learning on knowledge and comprehension level (Bloom's taxonomy (Bloom, B.S., 1956)). This learning must then be further developed to reach higher learning levels (application, analysis, synthesis, and judgement (Bloom's taxonomy) through work with the project.

# What must be assessed and how?

In general an assessment must examine if the given aims for an activity (in this case study activity) have been reached. If the students are to receive a feeling of the assessment being fair, and if the evaluation achieves the aims for the assessment (assessment of and feed back to the student, verification of the quality of the education from the authorities and the industries working with the graduates, and the quality assurance and control in the university [Hansen, I.L. & Rosenorn, T, 2005]) it is extremely important that the goals to be assessed are detailed and accurate and the scope of the assessment is known and agreed upon by all parties involved.

For students learning through work with problem based projects, what needs to be assessed for the project unit must be the general goals and aims described for the project unit, combined with the more detailed goals developed by the students during their project work. Typically, the goals are divided into cognitive classifications in the disciplines taught in the project supporting courses, i.e., cognitive learning in the individual disciplines and in the ability to work with and apply this knowledge and understanding across all the disciplines and in the context of the project. Also, non-cognitive competences must be assessed when they are part of the learning goals. These goals can be far more complex and difficult to assess objectively.

Competences such as thinking and working in an analytical way are reasonably easy to judge objectively. In this case as assessor you can ask questions about the choices of what has been included or excluded in the work and the reason behind these choices. Here all five of the criteria for a fair exam described above can be met.

The situation is different when collaborative skills and communicative skills (oral, written, and visualisation) are parts of the competences that must be assessed. I have no doubt that the assessors personal preferences have a significant influence on the outcome. When you assess a person's skills in communication it is extremely difficult for all examiners to live up to the first two of the five basic rules for good assessment:

1. Assessment is a judgement based on performance, not personalities.
2. Assessment is a judgement based on evidence, not feelings.

In regards to oral communication, it is the entire experience (including the feeling you get) and the personality of the person one is communicating with that determines the result of the communication. Further, it is important to realize that we as persons have different preferences for receiving information: some receive information through listening and some through visualizing.

If the student and the assessor have different preferences, this will (in my personal experience of working with external examiners with different preferences than my own) influence the judgement of what happened during the examination and consequently, also the mark.

*In my opinion* this does not mean that assessments which are not completely objective should be avoided. If this was the case we would not be able to assess some of the competences like communicative and collaborative skills that are desired by society. We need to make sure that these competences are given the correct weight in the assessment. The assessors can not focus solely on "form" or "content", they must realize that there is a well defined balance between the two.

# Project unit assessment at Aalborg University

## An example from a master program in Chemical Engineering (Oil & Gas technology)

On the seventh semester (1st semester of an international master education) the disciplines to be learned cover:

- Chemical unit operations
- Materials science
- Oil chemistry
- Thermodynamics

And further as this is an international program where students not familiar with POPBL are accepted the aim for the project work also covers:

- Problem - and process analyses
- Communication
- Collaborative learning
- Group work and solving conflicts in groups
- Project management
- Time- and resource planning

The project subject can typically be: an extension of the production capacity of an existing oil or gas producing facility. This project then becomes the means to acquire deeper knowledge of the chemical engineering disciplines and develop the students' competences in the process and management areas.

At the presentation of the students' work that takes place during the assessment seminar the individual student during the first phase of the seminar has only presented a small fraction of what the group has worked with (and learned) through the semester. As the learning goals are the same for all the students in the group, it is the examiners task (duty) to ensure that all students are asked questions about the goals within *all* the learned disciplines as well as in what has been learned about work processes including, communication and the methodology used to make the project and attain the specific learning goals.

In the literature about assessment different methods to keep track of the performance and examination of the individual students using different types of lists or matrixes are described.

In all cases the main idea is to prepare the examination in a way so that all goals are assessed by all students.

The students must have individual marks and as an examiner you have to devise a strategy to distinguish marks for each student who has worked together in the project group for half a year.

# The individual marks of students working together in groups with the same project

It is a very strong wish from the students as well as from all other stakeholders in educations that the marks obtained by the students reflect the actual learning level and each individual student. This is off course reasonably easy to accomplish if individual examination is performed. The limitation to this is when it comes to assessment of collaborative skills and communication together with other people. If this is a goal it also must be assessed and this is in my opinion only possible if the group is assessed in an examination where the entire group is present.

As already described above this only requires good planning from the examiners involved. But the argument that there is too little difference in the marks given to the individual students in a group is still important to consider and discuss if this is relevant and true.

The first thing to consider is: should we expect a great variation in the learning level within a group? This I think depends on when in the education the project takes place and how the groups are formed.

In the first semesters where the students yet not know each other and have different initial level of qualifications and competences when they enter university one must expect rather inhomogeneous groups which as a consequence may lead to different levels of learning for the individual stu-

dents. The result very mush depends on the effort the student put into studying and the ambition of the individual student.

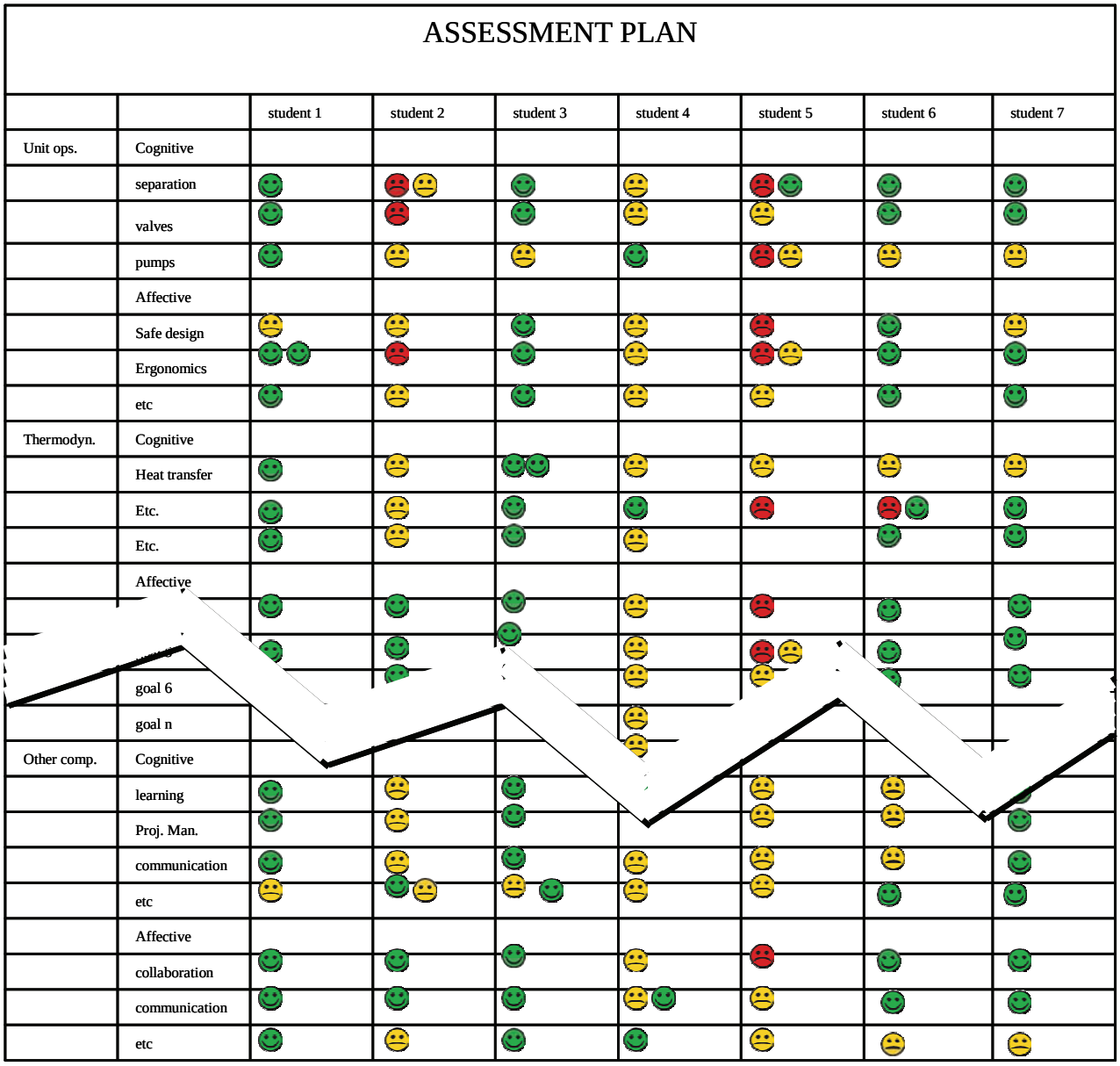
This problem may continue throughout the education if groups are formed administratively because if so there is no regard taken to the individual student's ambition and level of qualifications and competences.

If on the other hand the students are allowed themselves to choose their group mates our experience is that they choose students at the same level as themselves and with the same ambition level. In these cases one shall not expect major differences in the marks of the students from the same group but one can expect greater variation in the marks given to different groups - in this way in a very valid way reflecting the difference between the individual students.
The complaints we get from students about the marks are usually due to the fact that they are new in the system and don't know each other. This is off course a problem to try to overcome.

The second thing to consider: is the way we give the marks supporting individual assessment or is it equalising the marks? The answer to this question may be the basis for solving the above dissatisfaction of some students.

The first condition to solve this problem is to make sure that all students have been asked questions covering all the learning goals of the project work. To keep track of this a form like the one shown next page (fig. 1) may be helpful.

Figure 1: Form for planning and keeping track of individual student's performance during an examination.




As a preparation to the examination the examiner writes down the disciplines to be assessed in the first column of the form showed in fig. 1. In column 2 the detailed topics under each discipline are listed representing cognitive as well as affective aims for the learning through the project. At the top of the rest of the columns the individual students' mnames are listed.

During the examination the coloured Smileys (or any other symbol chosen by the examiner) is used to show in which areas the students have been asked questions and the quality of their answers.

During and after the examination it can then easily be checked that all students have been asked questions in all areas and the quality of their answers. After this giving marks is farly easy and the marks easy to argue if questioned.

The next thing to consider is that the mark for a project work is made up o two parts:

1. a mark for the project report
2. a marks for the oral presentation and examination

These two marks are off course based on the learning demands for the project work as described above. I will in the following focus on the equalizing function of the mark given for the project report.

At Aalborg University we see the learning through the project proven partly through the project report and partly through the oral examination (assessment seminar) and we only give the student 1 mark made calculated as:

Mark for project * $F_1$ + mark for oral presentation * $F_2$

Where $F_1$ and $F_2$ are the fractions each of the marks contribute with in the total mark.
($F_1 + F_2 = 1$).

This equation means that the weight of the report in the assessment is crusial to the validity of the examination as a proof of the individual student's level.

If for example $F_1$ is set to 1 (mark given only on basis of the report) all students from a group get the same mark. If $F_2$ is set to be 1 (report does not count) the motivation to make a good report vanishes and the competences of written communication and most likely the collaborative skills are not developed. So it is a balance to choose the weight in the assessment situation.

As marks are different in different countries I have tried to illustrate the equalizing factor with some examples where I use % "correct" answer as the mark.

| Student | Mark report | $F_1$ | Mark oral part | $F_2$ | Mark total | Equalizing effect |
|---|---|---|---|---|---|---|
| 1 | 80 | 75 | 20 | 25 | 64 pass | high |
| 2 | 20 | 75 | 80 | 25 | 35 fail | High |
| 3 | 80 | 50 | 20 | 50 | 50 pass | medium |
| 4 | 20 | 50 | 80 | 50 | 50 pass | medium |
| 5 | 80 | 25 | 20 | 75 | 35 fail | low |
| 6 | 20 | 25 | 80 | 75 | 64 pass | low |

| Student | Mark report | $F_1$ | Mark oral part | $F_2$ | Mark total | Equalizing effect |
|---|---|---|---|---|---|---|
| 1 | 75 | 75 | 20 | 25 | 61 pass | High |
| 2 | | | 50 | | 69 pass | |
| 3 | | | 90 | | 79 pass | |
| 1 | 75 | 50 | 20 | 50 | 48 fail | medium |
| 2 | | | 50 | | 63 pass | |
| 3 | | | 90 | | 83 pass | |
| 1 | 75 | 25 | 20 | 75 | 34 fail | low |
| 2 | | | 50 | | 56 pass | |
| 3 | | | 90 | | 86 pass | |

# Discussion and summary

Literature about assessment is very comprehensive. Many good ideas and advice can be found on how an assessment can be fair and showing the truth when cognitive and psycho-motor learning is being assessed. When we are talking about affective learning and the learning related to collaboration, communication, conflict solving, etc., fulfilling answers are hard to find.

One of the demands of an assessment that is almost always mentioned is that it has to be objective. This may be possible within the individual disciplines when cognitive learning is assessed, but it is hardly possible where development of values, culture, and attitudes are part of the learning goals.

Another demand is that the assessment must not be influenced by the student's personality. This may also be possible in most cases, but when for instance communication competences are to be evaluated, personality is one of the major factors for successful oral communication.

When and if competences and not only qualifications are to be assessed a certain degree of subjectivity from the assessors is unavoidable. And competences must be assessed, because competences are the basis for how people function in their work together with other people and it is also the focus in the work market.

If only cognitive or psycho motor learning is to be assessed, the assessment can be more objective. When assessing cognitive learning the learning depth is the challenge, and assessing psychomotoric learning first becomes a real problem if it includes an artistic element.

All these aspects have to be taken into consideration during the planning and preparation of an assessment, and in particular it should be kept in mind that *what* is assessed and *how* it is assessed must be known by all involved parties – students, examiners, and external examiners. Only in this way can a reasonably fair and just assessment be made of POPBL projects.

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