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From Pupil to Student - a Challenge for Universities: an Example of a PBL Study Programme

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Aalborg University, Aalborg, Denmark, has organised the first year of studies at the Faculty of Engineering and Science in such a way as to meet the special needs of students when they enter a new education system. The students are introduced to the so-called Aalborg Model of Problem-Based Learning (PBL). The article gives an overview of the structure of the first two semesters, showing examples on how students' basic technical skills can be developed, as well as introducing the students to the philosophy of the Aalborg Model of PBL. Further, it is illustrated how students can acquire general and transferable skills when collaborating, and how they can evaluate a technical solution in a particular context. The established platform for academic methods of work and study is also presented and elaborated on.

INTRODUCTION

One problem facing modern education is how to adapt quickly to an ever-changing world and to keep up with an almost exponential growth of knowledge. The knowledge that students can acquire within a given timeframe is limited, so they will know relatively less of the current knowledge available when they finish at a university, compared with the knowledge present when they actually started. Such a situation calls for more innovative educational systems.

At Aalborg University (AAU), Aalborg, Denmark, the focus is shifting towards endowing students with skills and competences to seek and utilise new knowledge independently. However, this means that the focus must be different for the programme planning when compared with traditionally taught courses. The aim is to make students learn by themselves, independent of teachers and the institution. It is believed that by having students undertake projects supported by courses, they will develop competences that make them capable of working in a changing world and developing new knowledge independently.

EDUCATION AT THE FACULTY OF ENGINEERING AND SCIENCE

The first year of studies within the Faculty of Engineering and Science is a so-called year of basic studies. It is the first year of continuing studies at the university, which forms an integral part of the programmes for BSc (Eng), MSc (Eng) and Cand.Scient. of the Surveyor programme. Students enter the first year of a programme but do not enter a separate one-year education programmes.

During the first year of studies, students learn to adapt to Problem-Based Learning (PBL), along with the acquisition of necessary basic knowledge within the fields of mathematics, physics, information technology, and discover the relationships between technology, as well as the context in which the technology appears.

The first year also focuses on developing academic maturity, which calls for the ability to work independently (independent of facilitators or teachers), to develop collaborative competences, critical attitudes and a professional engagement towards work. The project-organised and problem-oriented project work carried out in teams forms the study learning environment.

Two periods divide the first semester: a pilot project and a longer project lasting for the rest of the semester. The second semester is one continued period as shown in Figure 1 [1].

The pilot project is an introduction period where students become acquainted with the University and the problem-based study philosophy. During the pilot project period, which is four weeks long, students undertake a small project, write a report and present it at a seminar.

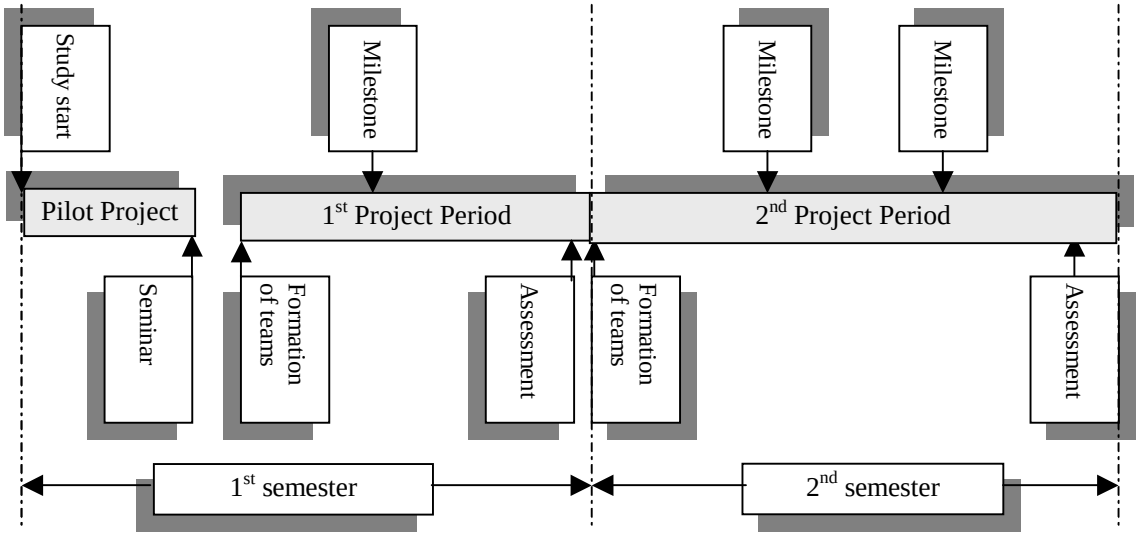

Figure 1: The structure of the first two semesters [1].

The first project period is the more complex project that the students initially perform and it gives them the opportunity to have width, as well as depth, in technological project work.

The second project period, in the second semester, is the longest project period where students need to work in greater detail with a chosen technical-scientific and complex problem.

An assessment concludes each of the project periods and includes an evaluation of the courses that support the project work for the given semester. The project assessments are part of the students' learning process, the principle of which is to focus on an academic discussion rather than a traditional interrogation. Even though the assessment is of the team, each student obtains an individual mark.

SEMESTER STRUCTURE

The sememster structure is illustrated in Figure 2. In short, the semesters consist of three elements: the project (50%), project supporting courses (25%) and non-project supporting courses (25%). The project and the project supporting courses involve 75% of the students' workload during the semester.

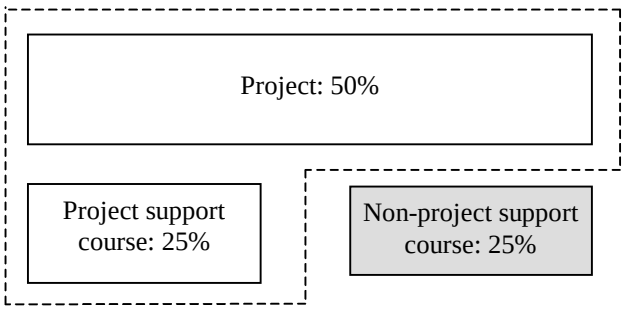

Figure 2: A typical semester structure.

The assessment evaluates both the project and the project supporting courses. The non-project supporting courses are evaluated by project independent evaluations.

Objectives for the Basic Year

Bloom's Taxonomy forms the bases of the description of the objectives [2]. The overall objectives for the basic year are:

- To introduce students to a scientific way of working with a special focus on methodical competences.
- To qualify students in their continuing studies within the Faculty of Engineering and Science at Aalborg University.
- To train students to take responsibility for their own learning process and guide them on choosing the right programme [3].

The overall objectives cover the following three areas of professionalism:

- *Technical-scientific professionalism*: After the basic year, students should be able to comprehend and apply technical and scientific methods, models and theories on the bases of a real problem.
- *Contextual professionalism*: After the basic year, students must be able to comprehend and apply methods for analysing and evaluating technical and scientific problems, while also taking into consideration relevant relationships and/or perspectives.
- *Professionalism of project work*: After the basic year, students must be able to undertake a

learning process based on project-organised and problem-oriented project work performed in teams. Furthermore, the student must be able to present the project results, as well as the learning process itself.

Variety and Progress across the Semesters

The first year of basic studies has a clear progression throughout the two semesters in order to achieve its objectives. Table 1 shows this development of the objectives, theme and project proposals, while Table 2 shows the number of ECTS (European Credit Transfer System) points for the courses and for the project (one year of full time study is equivalent to 60 ECTS points).

The overall profile for the two semesters is to have a very broad entry, which then narrows towards the characteristics of a specific programme after the second semester. The model is the so-called *modified hourglass model* (developed by Moesby and Rosenørn) (see Figure 3). This model illustrates the variations during the programme starting with a wide contextual entry, which, in the middle of the study, tightens to focus more on disciplines, ending up in wide technical and contextual projects that reflect the complexity of real-life problems. It also illustrates the choice between a specialised research-oriented career or a more wide technical/ industrial career. The basic year is the first part of this model.

Table 1: Objectives, themes and project proposals throughout the project periods [3].

	Pilot Project	1st Project Period	2nd Project Period
Objectives	Wide overall intro-duction	General methods in focus	Specific methods in focus
Theme		Reality and models	Modelling reality
Project proposals	None	Programme-oriented but very open and wide	Programme-specific proposals

Table 2: ECTS points for project, project supporting courses and non-project supporting courses in the semesters [3].

Elements of the Semester	1st Semester	2nd Semester
Project	15 ECTS	15 ECTS
Project supporting courses	8 ECTS	7 ECTS
Non-project supporting courses	7 ECTS	8 ECTS
Total	30 ECTS	30 ECTS

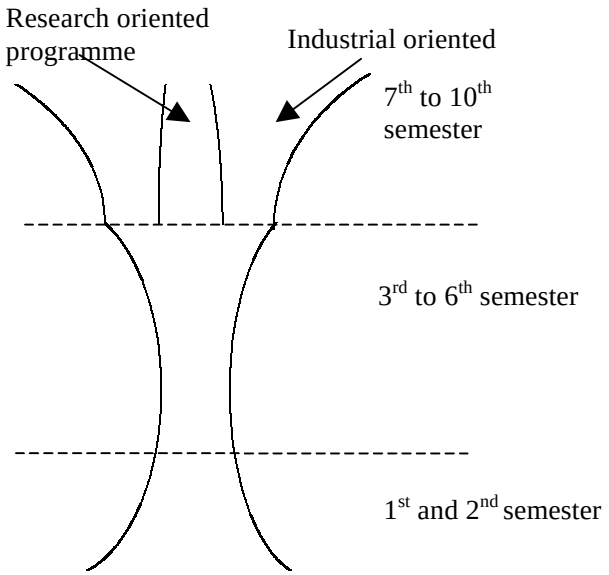

Figure 3: The modified hourglass model.

TEACHING AND LEARNING

When initially introduced to the Aalborg Model of education, a person may be left with the impression that the Model is rather static. However, it is in fact a very dynamic model, which makes it easy to implement new teaching techniques or new learning methods, based on the latest research results or changes in a programme curriculum.

As the focus is on student learning, the best possible methods to support their learning must be found. The technique used in a course depends mainly on two things, namely:

- The topic taught.
- The teacher.

The topic taught calls for different teaching models and in the basic year, a variety of models are utilised, including the following:

- Traditional lectures with large groups of students.
- Individual problem-solving assisted by tutors;
- Traditional classroom teaching in smaller groups;
- Case studies;
- Role-plays;
- Self study;

- Excursions;
- Guest lectures from industry and other institutions.

The best teaching technique for the course is determined by the nature of the course, the learning that the programme seeks to facilitate, and the capability of the teacher.

Students learn to collaborate during teamwork exercises, as well as the lecture courses in *Collaboration, Learning, and Project Management Courses* (CLP courses) that support their learning (see Table 3).

METHODS AND MODELS USED

In order to achieve the objectives for the basic year, the initial focus of teaching is different to that in later semesters. As mentioned previously, the basic year is a transition year and, because of this, different methods support this transition to encourage students to leave their high school habits behind in order to develop into university students. If students are to develop certain competences and skills, courses need to be offered that specifically focus on achieving these learning goals (see Table 3).

Apart from the courses on, for example, learning theories, collaboration, ethics, planning, scientific methods, academic work and methods for project work, students are also introduced to methods of reflection (milestone activities) and reference, learning portfolios, and academic formalities during the first two semesters.

Students are introduced to working in a formal manner in the generation of projects. By making students follow the model shown in Figure 4, they are introduced and guided to a scientific approach to project creation and problem-solving. Students are thus enabled to fulfil part of the objectives for the first two semesters of their programme. Besides showing the general model of phases in a project work, the model

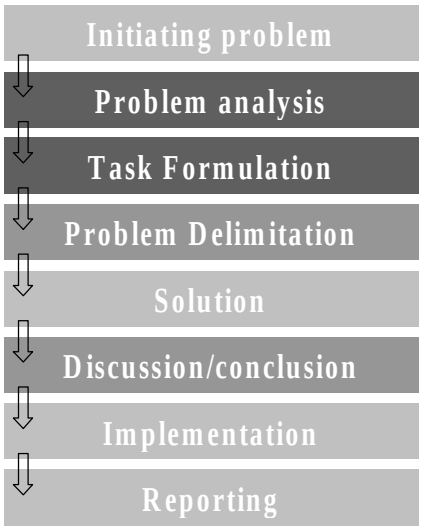

Figure 4: The formal phases of the project. The shadings indicate potential difficult collaborative periods in teamwork.

also shows where students will probably experience major difficulties in the collaboration during the project. The lecture courses introduce theories and the background to deal with those periods of difficulty, and to make it possible for students to solve problems by themselves.

The model also helps students to avoid starting projects by first entering the solution phase, but rather to start the project work by making thorough analyses and formulating the real problem they wish to solve.

The project work is carried out within a defined area, which merges a defined theme, the given courses and the formulated project proposals. All of these are in accordance with the aims set for the semester and student learning. The model in Figure 5 illustrates the correlations between these elements.

By defining a theme and identifying the courses for the semester, it is easier to formulate project proposals that utilise the courses in the project

Table 3: Content and progression of courses through the project periods [3].

Project Support Courses	Pilot Project	1st Project Period	2nd Project Period
Collaboration, Learning and Project (CLP) management 2 ECTS	Report writing	Communication, learning, presentation, and planning	Collaboration and planning
Technology, humankind and society (TMS) 2 ECTS	Problem analysis	General TMS professionalism	Programme-specific contextual professionalism
Engineering and scientific methods 2 ECTS	General methodical competences		Programme-specific methodical competences
Technical Courses 4 ECTS	None	Ad hoc Courses	Programme-specific courses

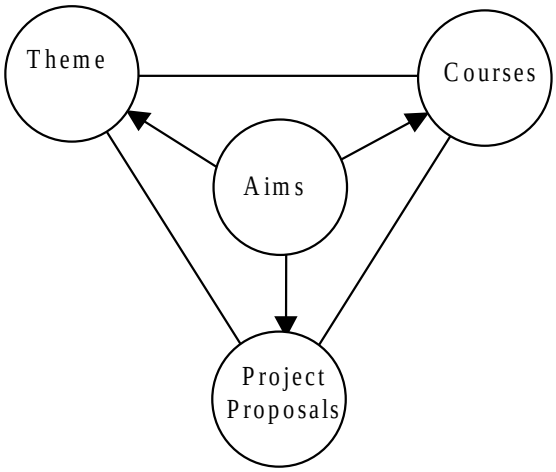

Figure 5: Relationship between theme, courses and project proposals [1].

work. This also makes it possible for students to fulfil the aims of the project work.

PROFESSIONAL WIDTH AND OPPORTUNITIES FOR DEEPER UNDERSTANDING

It is important for students to recognise the complexity of a technical-scientific problem and the possible solutions available. It is equally important to develop students' abilities by facilitating a deeper analysis in the chosen aspects of the problem and allowing for one or more potential solutions to the problem.

The project supporting courses are intended to enhance students' comprehension in a given topic and, through the project, students have the opportunity to venture deeper into different topics in the courses.

The relationship between courses taught and the actual project is one of the most important issues in order to make room for wider competence development, as well as the possibility for students to journey deeper into one or more topics or areas in their project work.

The semester is structured in such a way that the complexity of the project increases during the periods shown in Figure 1. The students develop a more qualified way of realising projects, which increases the depth in their capability of handling more and more complex situations in all three stated areas of professionalism.

REFLECTION SESSIONS

In the basic year, reflection becomes a routine element for students. The reflection sessions are based on the theories of Schön, as stated in *The Reflective Practitioner* [4]. This was further developed by Cowan [5]. In short, during each of the two semesters, students undertake *reflection before* (at the start of the semester), *reflection in* (milestone activity during the semester), and *reflection on* (at the end of the semester) the learning they have to start or have been through as a team and as individuals.

The team prepares a separate report, a *process analysis* (a reflection document), which describes and analyses the learning and evaluates the semester. The problem analysis is a part of the assessment (see Figures 6 and 7).

ASSESSMENT AND EVALUATIONS

In the basic year, there are two types of evaluations:

- Evaluation of the non-project supporting courses.
- Assessment covering the project, the project supporting courses and the learning document (process analysis) (see Figure 7).

The assessment is considered part of the students' learning process and is conducted on an academic discussion, rather than a traditional control of the student's knowledge. In order to establish an evaluation method that matches the educational model, students must be tested on the higher levels of Bloom's Taxonomy, as specified in the study regulations. A discussion, based on the project, uncovers the level of understanding possessed by the student.

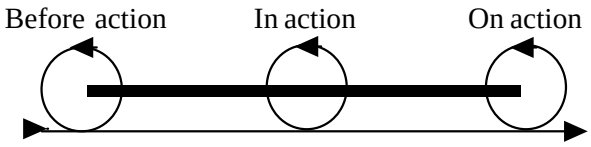

Figure 6: Cowan's *loopy diagram* for reflections before, in and on action during a semester [4].

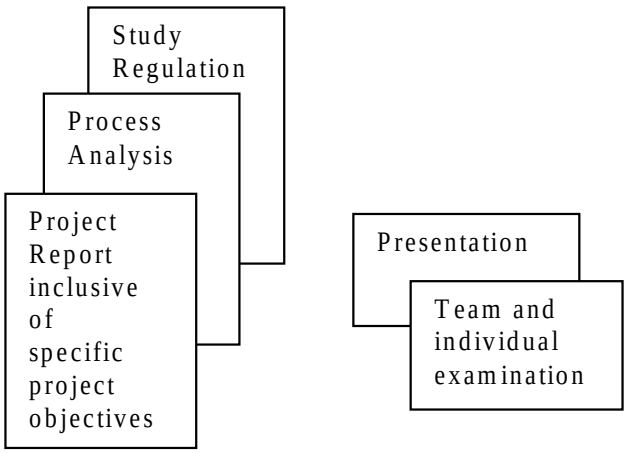

Figure 7: The basis for an assessment in the first year.

The assessment of the project work is carried out in teams and consists of two parts. It begins with a student-conducted presentation of the project work and the process analysis. Then a supervisor conducts a question session with the students, based on the presentation, the report and the process analysis. This question session should aim at identifying the level of competences each student has acquired, in order to be able to give an individual mark.

The traditional single course evaluation will not be described here in detail, but changes are now being made in the evaluation of the non-project supporting courses. Instead of a traditional written examination, an assessment based on the problems solved during the semester is planned, as well as a discussion on the mathematics taught and problem solving.

WHY A BASIC YEAR?

The basic year is the first year of university studies at the Faculty of Engineering and Science, AAU, and the focus is very much on learning and forming desirable study habits. The basic year is a bridge between the high school level on the one hand and the later semesters in the different programmes on the other. In the later semesters (ie beyond the second semester), students are expected to become comfortable with the philosophy of the educational model and to be able to work independently. They are also expected to take a higher degree of responsibility in their own learning process. Furthermore, they should possess a variety of competences for working professionally in teams.

Project-Oriented Learning (POL) is not (yet) an educational model with which students are familiar when starting at a university level. The progression of the basic year allows for the increasing comprehension in POL because of the way it is structured. The transition from a high school pupil to a university student is a time-demanding process, and it takes a certain amount of time for the student to go through these changes in attitude and values in order to take responsibility for their own learning. This is an often over-looked factor when institutions make changes to the PBL/POL techniques [6][7]. Furthermore, it is necessary to support students in this process by offering courses that focus on, and provide support in, their transition in the learning process.

Students have expressed that the opportunity of choice is a major factor when choosing between various universities and programmes. Since it is not possible to give students absolute freedom of choice in any programme, the solution is to create room for students to make some choices within the curriculum, as well as to ensure that the necessary learning objectives are met in a given programme.

Figure 5 shows the relationships and how they generate conditions by setting up a theme, choice of courses and development of project proposals for the semester. By giving students the opportunity to choose between *several* different project proposals – *all* matching the prescribed conditions – students feel that they have the opportunity to make their own choices. Ownership of the project work is a very important motivating factor for the student who is learning about the project environment. The feeling of ownership is one of the most important driving forces for students.

As stated in the overall objectives, the basic year also serves to help students choose the right programme. After the first semester, a student can elect to change programmes without extending the actual study time. After the second year, it will still be possible to change programmes, but the student must follow some of the courses taught at the second semester, or else catch up with the missed requirements by individual study. However, this is limited to one or two courses.

Students will not extend their study time by making a programme change after the second semester either. Students express this as a highly valued opportunity and it is cited as one of the reasons for choosing Aalborg University [8]. Having the opportunity to change programmes, students continue their studies based on the knowledge already gained of the programme chosen. Hence, it is unlikely that they will drop out due to unfamiliarity with a given programme.

THE BASIC YEAR AS A PEDAGOGICAL LABORATORY

The basic year serves in practice as a pedagogical laboratory and training centre for the academic staff. Since the students' learning, pedagogy, and general methods and competences are strongly in focus, the departments can, and do, use the basic year to train newly employed staff in the teaching model used. Experienced staff, on the other hand, can develop and test new educational techniques or test new methods when teaching these students.

One example is the implementation of Information Technology (IT): teaching mathematics can be tested and evaluated as there are several reference groups available for comparison. If successful, it can be implemented on a full scale basis. Formalised reflections are one of the elements that were developed in the basic year, and the model is now being implemented in later semesters in some programmes.

RESOURCES

In order to complete the description of the basic year, a discussion of resources is also important. By having a large number of students, there are opportunities to optimise study in several ways.

The educational costs per student are less at the basic year than in later semesters. This is possible by utilising resources more efficiently when having a substantial number of students, compared to having students divided into classes in different programmes. However, this does not compromise the quality of student learning.

The resources *saved* in the first year can be used in later semesters to compensate for the extra resources needed when having fewer students in the teams.

The development of collaborative teamwork skills calls for a certain team size. In very small teams, students will most likely not experience collaborative problems and larger teams tend to break into two separate working sub-teams. Experience shows that the optimum number is not less than five students and there should be not more than seven or eight students per team. The average at the basic year is typically between six and seven students per team. Teams of five or six students are generally accepted as an ideal team size. In later semesters, teams can be smaller: maybe two to three students.

Classroom teaching of courses is carried out in major groups that consist normally of between 60 to 140 students. There is one teacher lecturing in the auditorium. The process of solving problems, such as encountered in mathematics, is done in teams with the help of a tutor, who is usually a student from higher semesters.

DISCUSSION

As can be seen, there can be some dilemmas encountered in the study programme and these can be found mainly in the following areas:

- The need to give individual training in basic knowledge on the one hand, and cross-disciplinary project work on the other hand.
- The content of the project supporting courses and the use of those courses in the project work.
- The dilemma that stands between the individual student and the team in the learning process and in the assessment.
- Awarding individual marks in a team assessment that students consider fair.
- Social relations give low dropouts, but this success in the low dropout rate calls for an infrastructure or an environment that permits the development of strong social relations.

The basic year deals with these dilemmas and, in the planning of the semester, the Faculty tries to solve such related problems. With reference to the evaluation report of the basic year in 2000, it can be seen that the first year has been successfully structured with respect to the dilemmas stated [9].

The advantages of having a common first year of studies, where students develop general and transferable skills in order to improve their continuous education, outweigh the disadvantages. The main advantages are:

- An independent study board deals with the special pedagogical and didactical issues that are different to those of later semesters.
- The ability to optimise teaching, which saves resources that can be better utilised for specialisations in later semesters.
- Students are in an environment where their learning is in focus. Technical professionalism is equally in focus with contextual professionalism and the professionalism of project work.
- The focus is on the students' transition from pupils to students.
- The development of general and transferable skills benefits students in further studies.
- Students receive a good general entry to the University.
- Students have the opportunity to test the study they have chosen before making a definite decision on a particular programme.
- Students have the opportunity to change programmes without losing a year of study.
- Minimisation in the dropout rate is observed.
- The basic year serves as a learning laboratory.

SUMMARY

In 2001, the basic studies at Aalborg University and Roskilde University were evaluated by the Danish Evaluation Institute. This evaluation concluded that the basic year of the Faculty of Engineering and Science at Aalborg University appears to be well considered and has achieved a good correlation between objectives and the overall structure and individual elements [9].

It was recommended that further investigations should be carried out to find out why and how the basic year manages to have a very low dropout rate, and to make this more widely known in order to

inspire other institutions.

This article, as well as the ideas and issues discussed here, make the structure and content of the basic year known to a wider audience and may be considered a partial response to this recommendation.

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BIOGRAPHY

Egon Moesby was born 1952 in Denmark and has a BSc of engineering, civil and constructional engineering from Esbjerg Engineering College, Denmark. He was a consulting engineer at Anderskouv & Thomsen, Esbjerg, from 1981-1986, before becoming a consultant of international turnkey operations at Natural Gas Company Naturgas Syd. He was also a consulting engineer at Ramboll & Hannemann from 1989-1999.

Egon Moesby is currently assistant professor and associate professor at Esbjerg Engineering College and Aalborg University, respectively, since 1989. He was in charge of implementing the Aalborg PBL educational model at Aalborg University's Esbjerg campus between 1995 and 1996. Since 1996, he has been the Director of Studies and Head of the Study Board at the School of Basic Studies in Science and Engineering, Aalborg University. He is presently a Deputy Director of the UICEE Centre on Problem-Based Learning (UCPBL), a UICEE satellite centre, based at Aalborg University, and is involved with several distinguished engineering and educational advisory boards.

He is the author and editor of several publications and has participated in numerous international and national workshops, as well as satellite transmissions, particularly in the field of PBL implementation. His research interests include studying the changes in educational institutions when implementing a new educational programme.