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CHAPTER 91

PROJECT ORGANISED PROBLEM BASED LEARNING IN DENMARK [1]

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ABSTRACT

In this paper the "Aalborg Experiment" in engineering education is presented. The "Aalborg Experiment" is a project based innovation in university education. The paper is strongly based on the book by Kjersdam and Enemark [1] and on overheads produced by Fink [2]. Parts of the text are taken directly from Kjersdam and Enemark [1].

1. INTRODUCTION

About twenty years ago project organised studies were introduced at Aalborg University. It is fair to say that the experience since then has proven to be an important innovation in higher education.

In Aalborg University the curriculum in engineering as well as in the natural science is project organised from the day the freshmen arrive until graduation. The first year the freshmen learn to work in project groups. The next two years in the graduate programme the project work is mainly problem oriented.

In the design oriented project work the students deal with know-how problems which can be solved by theories and knowledge which they have acquired in their lectures. In the problem-oriented project work the students deal with unsolved problems within science and engineering profession. The project work has a know-why approach and is supported by relevant lectures. The duration of each project is one semester. In the programme half of the time is used for project work, 25% for courses

[1]Proceedings Structural Engineers World Conference, San Francisco, USA July 1-23, 1998. Elsevier Sciences, Paper P307-5.

related to the project, and 25% for courses related to the curriculum.

The project organised education demands a high degree of supervision and office space for the students. Each project group requires the use of an office at the university and continual supervision by a member of the faculty.

It is an effective educational system. 80% of the students pass their examination at the prescribed time and the Danish Parliament's state audit assessed Aalborg University to have the most effective educational system of the Danish engineering educational institutions.

The results and experience of the research carried out at the university are easily incorporated in the teaching programme because of their close relationship with problem solving, and because of their direct integration with the educational system and its programme. The graduates achieve great experience in interdisciplinary team work and they will normally possess the latest scientific and methodological knowledge, which is thus spread quickly and free of charge to both public bodies and industry, due to the employment of new graduates.

The engineering education in Aalborg has been evaluated and compared with traditional engineering education. This was done by two international panels, as well as by external examiners, alumni, and their employers and undergraduate and graduate students. The evaluation assessed that there was no difference in quality or level of engineers from Aalborg University and the other Danish engineering university in Lyngby. But the evaluation also assessed significant differences between the profiles of the graduates from the two Danish engineering universities.

2. ENGINEERING PROFESSION, RESEARCH AND EDUCATION

A successful engineering educational system depends to a high degree on the interaction between the engineering profession, research and education. The problems which are treated in professional practice and investigated in research are a good basis for combining practice, research and education. The society is getting more and more complex. In education we therefore have to face new problems and challenges all the time. The engineering profession is changing rapidly.

The traditional way of dealing with these challenges is in-service training, professional seminars, publications etc. However, this method of development is a slow process. We have to face the fact that traditional methods are not always adequate. A dynamic interaction between research and education is needed. Research is needed to produce new theoretical answers to problems, and close interaction between research and education is needed to produce graduates who are capable of producing practical answers, by applying new knowledge and skills.

3. TRADITIONAL HIGHER EDUCATION

Traditionally, higher education has been focused on rule-based disciplines with independent identities in their own context. In the discipline-oriented education, the special disciplines and theories are taught by means of textbooks and lectures. The students become experienced in the use of these disciplines and theories through the exercises and case work which support these theories.

The aim is specific knowledge in certain fields and standard solutions to known problems. In this tradition all undergraduates in the same study programme follow virtually the same curriculum and - hopefully - acquire the necessary and sufficient

knowledge in order to carry out certain specific functions in society.

4. PROBLEM-ORIENTED HIGHER EDUCATION

Problem-oriented education is based on working with unsolved, relevant and current problems from real life, e.g. the engineer's professional activity in an environment where solutions to real problems are sought. By analyzing the problems in depth the student learns and uses the disciplines and theories which are considered necessary to solve the problem posed, i.e. the problem defines the subjects and not the reverse.

The individual student - hopefully - acquires the necessary basic knowledge and information by means of literature and lectures and, through project work develops the ability to formulate, analyse and solve relevant problems. In principle, it can thus be ensured that the graduates have obtained experience to enable them to solve also the unforeseen problems of the future.

5. STRUCTURE OF AALBORG UNIVERSITY

The structure of Aalborg University is shown in a simplified form in figure 1. Aalborg University has three faculties and a number of study boards and departments. A study board is responsible for a certain education, e.g. civil engineering. They make study programme and ask the departments to give lectures and project advice. The departments perform the teaching and make research. There is a close co-operation between study boards and departments.

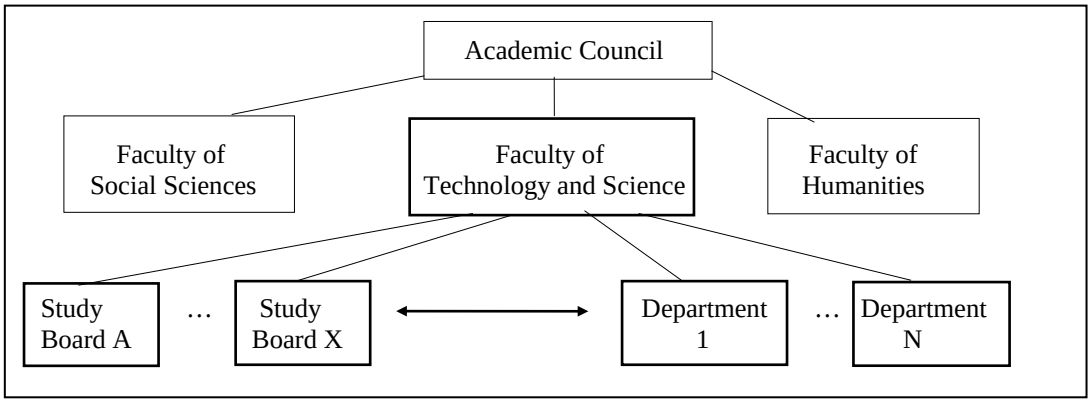

Figure 1. Structure of Aalborg University.

6. EDUCATIONAL MODEL

The educational model is based on the following five principles:

- Problem based learning
- Project organised teaching
- Group studies
- Interdisciplinary
- Integration of theory and practice

Problem based learning and project organised teaching are illustrated in figure 2.

In the first year (freshman year) the objective is

- Learn the way studies are performed at Aalborg University
- Learn basic theories and methods
- Give basic professional knowledge
- Give several options for later specializations
- Give a good basis for choosing the final specialization
- Give safe social surroundings
- Give an understanding of different fields of study.

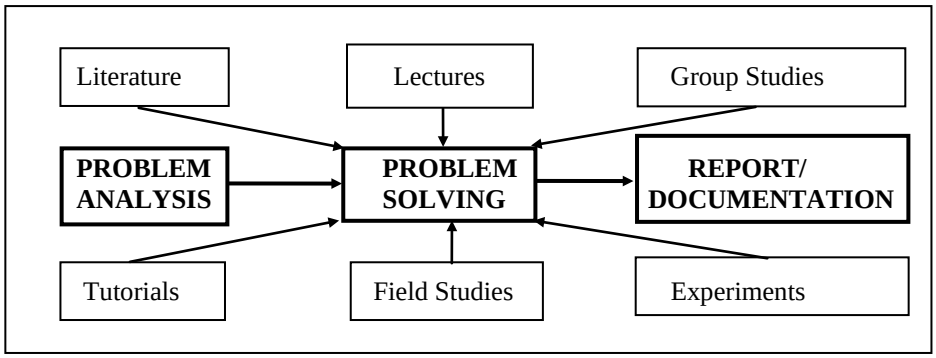

Figure 2. Project oriented - project organised learning.

7. IMPLEMENTATION OF SEMESTER PLANNING AND COURSES

For each semester a coordinator is nominated. His responsibility is together with a secretary to plan and follow the execution of the semester, including making semester study plans and week plans. A typical semester contains

Project work	15 modules
Project related course	8 modules
General courses	7 modules

i.e. a total of 30 modules. A module is defined as 20 hours of scheduled teaching (5x4 hours) +10 hours home work. Therefore, the work load for a student is 900 hours per semester. A semester is 20 weeks and it is divided in 3 periods. Each period is 5 weeks, and there are 5 weeks for self-study, examinations and preparation for examinations.

In order to provide for the use of project work as a basic educational element the curriculum is organised in themes covering a semester. The themes are chosen and organised according to the following requirements:

- The themes must constitute the professional profile of the curriculum.
- The themes must be organised in such a way, that increased knowledge and cognition can be obtained with progression during the study process.
- The themes must have a general expression in order to provide for a broad range of subjects for the project work carried out in specific themes.
- The themes must have a delimited professional approach in order to ensure teaching of the necessary disciplines through courses and fixing the professional perspective of the project work.

Before the start of the semester the students are divided into project groups of about 5 students each. During a semester the distribution of lecture courses and project

work is as indicated in figure 3.

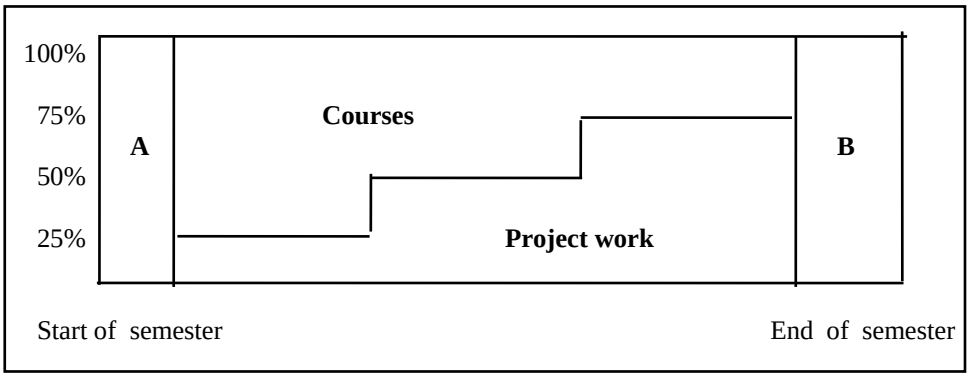

Figure 3. Distribution of courses and project work during a semester.
"**A**" indicates the introduction to the semester, and
"**B**" indicates the evaluation of the semester.

As indicated in figure 3, each semester has in principle an equal distribution of lecture courses and project work. But the study time is as shown dominated by lectures at the beginning of the semester and by the project work at the end of the semester.

8. PROJECT WORK

The aim of the project work is "learning by doing" or "action learning". The professional skills are established during the design-oriented project in the semesters at beginning of the study programme. Scientific cognition and methodological skills are established during the problem-oriented project in the later semesters.

The ability to present independent conclusions and to complete the project on time is also practiced. In fact the process of the project work at this stage is very similar to the problem solving process both in research and practice.

The project work also has pedagogical importance. Each student must be able to explain the results of his studies to his colleagues in the project groups and to the supervisor as well. This demand may be the clue to professional and theoretical cognition. In traditional education the students mainly restore knowledge presented by the teacher. Using the project-organised model knowledge and cognition are established during the discussions between the students in the project group, and often without the personal appearance of the teacher.

There are two different types of project work: the design oriented and the problem oriented work. The design oriented project work will normally be used to train the necessary knowledge and skills within the disciplines presented. The process and the contents of the project work will therefore be organised in advance. The supervisor will teach the students what to do, and the capability of doing it will be trained through the project work. The problem oriented project work is used mainly in the last part of the curriculum for establishing scientific cognition within the study fields chosen by the students. The project work here is centered on exploring and handling a problem with an unknown solution. The cognitive dimension leads to questions like:

Why is it so … ?
How come …?
What is the meaning of … ?.

The process will mainly be controlled by the students themselves. The choice of theories and methods will be supervised by a researcher; the product will be evaluated at the examination at the end of the semester.

9. THE SUPERVISOR

The supervisor in the project organised education model has to face other demands than the teacher in traditional education. Pedagogical skills for guiding the project work as well as skills for guiding the use of scientific theories and methods for analyzing the problems are essential. The supervisor has the responsibility of guiding the students to complete the project work on time, and in a defensible way according to methodological and scientific requirements. Normally the supervisor will possess a broad professional insight. But if the supervisor is not familiar with the professional subject, a second teacher should be attached to the group as professional deputy supervisor.

The supervisor also has to face the demands of constantly changing the contents of the courses, or developing new courses, according to the development of the profession, new research results and the changing problems within society. These demands may be seen as a challenge rather than a problem. They also ensure the continuous professional development of the faculty. However, a problem may arise regarding the distribution of the limited resources at the university since much preparation is required.

The project work carried out by the project groups promotes strong motivation for research by the teachers. In the project work, the problems and the choice of theories and methods are discussed with the supervisor. Many essential problems can be defined through the project work and be continued in the research which is carried out by the supervisor.

Many of the student projects may be based on the current research activities of a teacher. The project groups may e.g. analyse partial problems, theoretically or empirically, and thus contribute to the development of knowledge in fruitful co-operation with the teacher. The interaction between education and research thus allows for the development of the necessary dynamic element of innovative education.

10. PROJECT EXAMPLE

The theme in the seventh semester of the structural engineering education at Aalborg University is stress and stiffness analysis of structures. In the autumn of 1997 it was chosen to analyse a bridge girder (see figure 4).

The problem treated in this project is related to the fact that the classical beam theory cannot adequately describe the stress and deformations of the considered beam. Therefore, the objective is to clarify the modifications needed in the classical beam theory so that it can describe the stress and strains in a cross- section of thin profiles. The project is divided into a number of tasks as shown in figure 5.

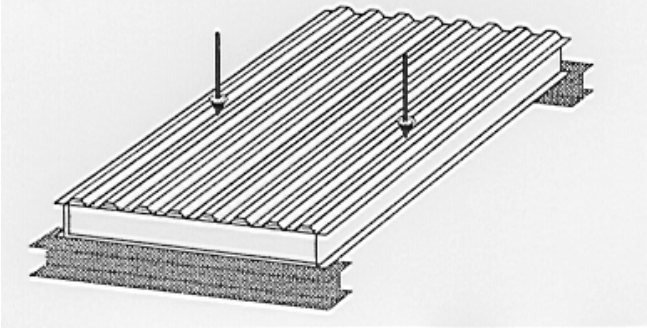

Figure 4. Steel bridge girder.

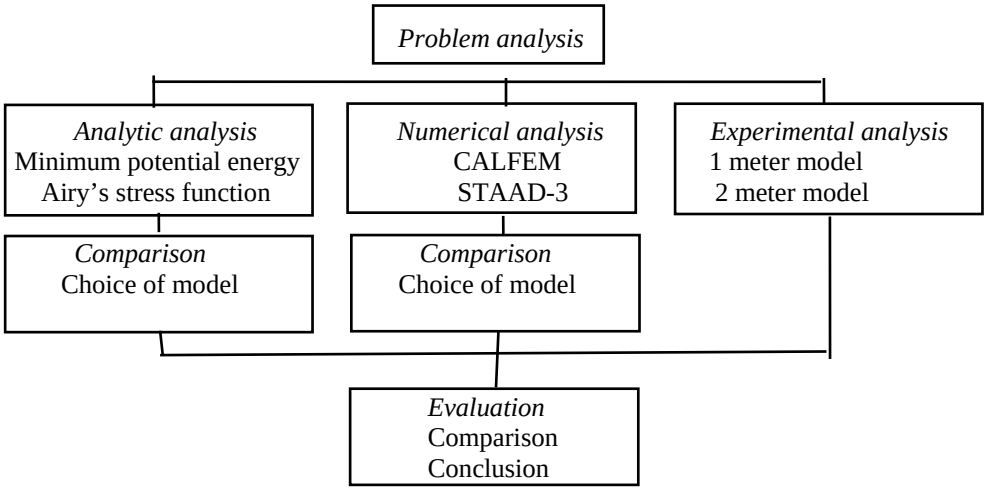

Figure 5. Solution strategy

11. EVALUATION OF THE AALBORG EXPERIMENT

An international panel commissioned by the Danish Ministry of Education to evaluate the international competitiveness of the Danish electrical and electronic engineering educations. This evaluation included evaluation of the project-organised studies at Aalborg University and a comparison with traditional university education; Arnbak et al. [3]. They recognize e.g. that "the novel problem oriented project-organised studies at Aalborg University are a real innovation in higher education as important as the Open University concept in the United Kingdom".

Another international evaluation process was carried out by an international panel, which had been commissioned to evaluate the Danish civil and construction engineering education; Christophersen et al. [4]. In connection with this evaluation a questionnaire was sent to all external examiners within civil and construction engineering in Denmark. The response was 55%. They were asked to assess the strength and weakness of he students, the examinations and the relevance of the education in relation to the labour market outside the university.

The conclusions from these panels and other evaluations are very extensive. Here some of the conclusions are presented on the basis of the work by Kjersdam and Enemark [1]. The international panels found that the students were very enthusiastic about group work and considered the group pressure to be a positive experience, but they also identified the formation of groups to be a difficult and painful process. The

students were also asked to assess the best semester in their curriculum. The assessment showed that the students did not appreciate the first semesters, when they were in lack of technical knowledge and scientific tools.

Students as well as professional engineers were asked to assess the balance between project work and courses in the curriculum where half of the time was spent on project work and half of the time on courses. The students as well as he professional engineers found the weight of the project work and the taught courses in the curriculum very satisfactory.

Concerning the demands of the studies on students these were mainly considered sufficient, but often too diffuse. With regard to the technical coherence in the program, most of the students found that the technical coherence was somewhere between good and limited. The feeling of diffuseness and lack of technical coherence is one of the weaknesses of the project-organised education's constant demand of innovation and up-to-date knowledge.

12. QUALIFICATIONS OF THE SUPERVISORS

The faculty of technology and science at Aalborg University has a traditional academic background, with an emphasis on research. They are therefore self-educated as supervisors for the project groups, even if hey have been given some training in project-organised education.

The students and the professional engineers also assessed the most important qualities that the supervisors possessed and qualities the students wanted them to possess. The assessment was made using Miller's list of ten teacher qualities; Miller [5]. There was a very good overlap between the profile the students and engineers wished the supervisors to possess and the qualities the supervisors actually possessed, namely 62%. The only important difference in the profiles was that the students wanted more precise and clear explanations than they got from the supervisors.

13. PROJECT ORGANISED LEARNING VERSUS TRADITIONAL EDUCATION

The international panels assessed the work conducted by the students during their theses. They found it of a quality equivalent to that of institutions with which Aalborg University is competing internationally. But the international panel also found that the engineers graduating from Aalborg University had significantly different skills when compared with graduates from a more traditional education.

The emphasis on synthesis and group culture at Aalborg University generates a graduate more readily adaptable, and thus more directly employable. On the other hand, graduates of a more traditional system with an emphasis on analysis are perhaps better grounded in fundamentals and more capable of working independently although in general they will require more on the-job training.

Aalborg University was found to put more emphasis on aspects of operational and interpersonal effectiveness compared with traditional institutions which focused on fundamental concepts.

Areas in which more than 5% of the engineers from Aalborg University had experienced better preparation compared with traditional engineering education were:

- Management and co-operation 29%
- Project work and problem solving 23%
- Communication skills 8%
- General technical knowledge 5%

The areas in which more than 5% of the Aalborg engineers had experienced a worse proportion were:

- Specialist knowledge 10%
- Fundamental knowledge 9%.

To conclude, the graduates from Aalborg University were stronger in management, co-operation, project work, problem solving, communication and general technical knowledge. However, they are weaker in specialist and fundamental knowledge.

14. CONCLUSIONS

The combination of problem-oriented and project-organised education in Aalborg University has proven to be an effective educational system, which produces readily adaptable graduates with strong qualities in problem-solving, communication and general technical knowledge. The weakness of the problem-oriented education is the students' lower load of specialist knowledge and methodology.

15. ACKNOWLEDGEMENT

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