



Revista Facultad de Ingeniería

ISSN: 0717-1072

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Universidad de Tarapacá

Chile

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Danish Engineering Education Has Changed
Revista Facultad de Ingeniería, núm. 8, julio-diciembre, 2000, pp. 61-64
Universidad de Tarapacá
Arica, Chile

Available in: <http://www.redalyc.org/articulo.oa?id=11400807>

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DANISH ENGINEERING EDUCATION HAS CHANGED

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ABSTRACT

*The Working Group on Curriculum Development of Société Européenne pour la Formation des Ingénieurs has recognized a need for more comprehensive presentations of European engineering education systems. This article describes the changes that Danish engineering education is undergoing. The titles *civilingeniør* and *diplomingeniør* are described, as are the institutions offering engineering education. Previously, there were two engineering societies in Denmark-now there is only one.*

INTRODUCTION

The general structure of Danish engineering education is currently undergoing a transition. Previously, there were three different types of engineering education, namely *teknikumingeniør*, *akademiingeniør* and *civilingeniør* [1]. From now on there are only two systems: *diplomingeniør* and *civilingeniør*. However, with approximately 60% of all Danish engineers being *teknikum* and *akademi*engineers, the former titles will formally exist for a long time to come.

The need for change arose from the fact that since Denmark has an entire population of 5 million, rationalization of its education systems is essential. Before the reform, there were 11 engineering institutions. With increased cooperation between institutions, there are now nine administrative units.

THE DANISH EDUCATION SYSTEM

Primary school is a 9 year compulsory education which formally starts with first grade at the age of 7. Most children attend a preparatory class at the school, when they are 6 years old. Tenth grade is not compulsory but is often taken by pupils not headed for secondary education or those in doubt as to their future education.

Secondary level consists of 3-4 years of school or vocational training. Previously, secondary school (*gymnasium*) was divided into a mathematics stream and a foreign language stream. There is no such division now, it having been replaced by the opportunity to study subjects at different levels: A, B and C level, with A level being the highest.

The main purpose of the secondary school is to prepare for university entrance. In general, direct admission to an engineering institution requires A level mathematics, B level physics and C level chemistry. Students with this background will also have studied two languages, English for 6 years and either French or German for 3 years. More than 50% of pupils go on to secondary school.

The tertiary level of education consists of universities, engineering colleges, business schools, etc. A detailed description of the entire educational system is given in Woolston and Dickey [2].

ENGINEERING DEGREES

As mentioned previously, there are, as of 1995, two types of engineering degree: *civilingeniør* and *diplomingeniør*.

Civilingeniør

This is a 5 year course aimed at development and research, and teaching. The closest international equivalent to the degree is the UK/US MSc. It should be noted that the degree covers a range of specializations, not only civil engineering. The Technical University of Denmark (DTU in Lyngby, near Copenhagen) and Aalborg University (AUC in Jutland) offer this title.

Diplomingeniør

This is a 3 1/2 year course, including half a year of practical engineering training in industry. The aim of the course is to provide the students with both the theoretical and practical knowledge required to practise

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as professional engineers in a design and development, consulting and supervisory environment. The closest international equivalent is the BSc. The diplomingeniør degree is offered at the above mentioned universities and at the engineering colleges of Copenhagen, Aarhus, Odense, Horsens, Sønderborg, Herning and Haslev.

Both universities, DTU and AUC, offer PhD. degrees for civilingeniør graduates. The average period of study is 3 years. The number of PhDs awarded annually has for a long period of time been very low. However, interest has increased and the number of degrees awarded doubles every third year and is now approximately 170 a year.

The academic year has two semesters. Each semester lasts 20 weeks, including examinations. The engineering degree courses are regulated by a common set of regulations produced by the Danish Ministry of Education [3]. Graduates of the diplomingeniør programme may continue studying for a further 2 years to obtain the civilingeniør degree. Thus, obtaining both degrees takes half a year extra. The two systems are not totally harmonized but a typical Danish compromise between tradition and internationalism.

Both the diplomingeniør and civilingeniør degrees give the right to become a member of The Society of Danish Engineers (IDA). The previous teknikum and akademi degrees also provide eligibility. IDA is a combination of a trade union and a learned society, taking care of its members' technical and financial interests. IDA was formed in 1995 by the merger of the two previous societies. IDA is the only engineering society in Denmark and is also a member of the European Federation of National Engineering Associations.

THE ENGINEERING INSTITUTIONS

All Danish education is free of charge and in principle open to everyone who fulfils certain entrance requirements. The requirements as to previous theoretical knowledge are in principle the same for all engineering schools. Students applying for admission must in general have passed the upper secondary school leaving examination (Stundente-reksamen) or similar education with mathematics at A level, physics at B level and chemistry at C level. These levels can be reached in several ways (this will not be described here: further details are described in Lange [4].

TECHNICAL UNIVERSITY OF DENMARK

DTU, with a branch in Helsingør former Engineering

College of Helsingør), offers both diplomingeniør and civilingeniør degrees. The civilingeniør degree at DTU is a 5 year research based course and is the most theoretical and science-based engineering programme. The course is modular and students form their own combination of modules. There are, however, some restrictions: 12% are compulsory in mathematics and physics and a further 11% must be chosen from a pool of mathematics, physics and chemistry modules. All other modules are, in principle, optional but the combination of modules must be approved by the university before a degree is awarded. Recommended curricula are prepared for the classical branches of engineering: civil and construction, chemical, electrical, mechanical, etc. It is possible to specialize in one of 20 different profiles, e.g. food science and technology, informatics and environmental engineering.

The pedagogical concept is the subject-oriented module, with lectures in large groups and laboratory work done in small groups or individually. The course is concluded with a thesis, equivalent to half a year's workload. The thesis is most often done individually. An average of 12 modules a year are required to complete the course in 5 years. The average student takes more than one year extra to obtain the degree.

The diplomingeniør degree course at DTU is also structured in modules. The modules are approximately the same size but the number is adjusted to the 3 1/2 years of study. For the first four semesters, the modules are compulsory, as is the practical training period. The practical training lasts for half a year and is usually taken during the fifth semester.

The pedagogical concept is the subject oriented module with class-oriented teaching for groups of 25-35 and laboratory project work done in small groups within the class. In the final semester, the students prepare a thesis, either individually or in small groups. There are several branches of study: civil and construction, chemical, food science and technology, production, naval construction, electrical and mechanical engineering.

Aalborg University Centre

The faculty of science and technology at AUC, with a branch in Esbjerg (former Engineering College of Esbjerg), offers both the civilingeniør and diplomingeniør degree within the departments of civil and construction engineering, building technology and structural engineering, mechanical, chemical, energy, export, bio-technology and information technology. AUC opened in 1974 and is the youngest engineering university in Denmark. It is quite different from most other engineering institutions in that it has a

problem-oriented, project-organized pedagogical concept.

The first year of study is common to all departments. After the second semester the students enter their chosen department. After the sixth semester, the students must choose between one more semester leading to the diplomingenior degree, or four more semesters leading to the civilingenior degree. Both degrees require a thesis to be completed in the final semester [5].

The Engineering Colleges

The engineering colleges, with institutions in Copenhagen, Aarhus, Odense, Horsens, Sønderborg, Heming and Haslev, offer the diplomingenior degree. The curriculum at each of the seven engineering colleges is modular in structure and based upon the same state regulations. However, owing to physical and geographical differences, there are variations in curricula and pedagogical approaches. The first four theoretical semesters are compulsory and are based on classroom teaching. Dialogue is encouraged between student and teacher during these sessions. In the fifth or sixth semester, half a year is spent on practical, industrial training. A final thesis must be produced during the seventh semester.

Some engineering colleges have combined modules into groups and have project work in these groups of modules. Up to 50% of the entire curriculum may be project-organized, thus emphasizing the integration of theory and practice. As is typical throughout the entire Danish education system, oral examinations are common. This promotes an ability to communicate and provides a better platform for the assessment of project work.

There are several lines of study: building and construction, chemical, mechanical, electronics, electrical, production and export engineering. Export engineering is a relatively new course, having started in 1985. It is a 4 ½ year course offered in Copenhagen and Horsens and is taught jointly by the local engineering college and business school. It takes a year longer since it incorporates technical, commercial and language skills. It is an exception from the general structure of Danish engineering education. It also has its own title: *eksportingenior*.

At the Engineering College of Copenhagen, the entire curriculum in electronics is taught in English as well as Danish. This makes the course attractive to both foreign students and Danish students who wish to improve their English.

Democratic Administration

Tertiary education in Denmark is different from that in most European education systems in the way it is managed. The system is democratic, with the academic staff, students, technical and administrative personnel all having formal influence in the institution's decision-making process. The dean is elected by these groups, as are members of the different boards responsible for the institution's finances and curricula. The curriculum development board is made up of 50% academic staff and 50% students. On other boards, the ratios may be four academics, two students and one technical/administrative staff member. Most board positions have a 3-year tenure.

Trends and Current Educational Issues

As mentioned previously, rationalization is the main trend in the 1990s. The objective is a simultaneous cost reduction and quality improvement. Some colleges had become quite small and experienced difficulty keeping up with the fast pace of technological development. Therefore the Danish government has chosen to offer extra financial support for mergers and increased cooperation and networking. As a result, the Engineering College of Helsingør is now a department of DTU and the Engineering College of Esbjerg is a department of AUC. Cooperation and networking between several of the other engineering colleges has also increased.

Project Organization

As mentioned above, AUC has the least traditional pedagogical approach. Both AUC and Roskilde University have had project-organized curricula for over 20 years. This has had a great influence on many other institutions in Denmark and has now reached a point where Danish industry is not only asking for the general qualifications but also looking for project work, problem-solving skills, teamworking and communication skills. This trend is of course not just a Danish phenomenon. It can be observed throughout Europe but is perhaps at a more advanced stage in Denmark.

CONCLUSIONS

The diplomingenior degree programme, introduced in 1995, is now firmly established as the trend of rationalization in order to improve the quality and reduce the cost of School of Business and Engineering, Odense University and South Jutland University. A significant factor in the development of engineering

education in Denmark has been to conclude, the face of engineering education has changed dramatically over the past.

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