

CHANGING CURRICULUM BIT BY BIT

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Abstract

The engineering education at Aalborg University is based on problem based and project organized learning. All engineering programmes start with a first year education, the basic year where the structure and overall content is within the same study regulation, and at the same time the basic year is divided in subgroups related to each of the 16 engineering programmes. It means that the overall structure is the same and basic courses as mathematics and physics are the same as well as cooperation, project management and learning. Other technical courses are directed towards the specific engineering programme. During many years there has been a discussion about the content and the value of the technical courses, especially mathematics and physics. Students complained about the teachers as well as the content. The courses were slightly changed and the teachers were replaced, but this was not enough, students did not find the subjects interesting, and they were not satisfied.

During the last years new engineering educations are established at Aalborg University. One of them is Architecture and Design, a master programme with specializations within architectural design, urban design, industrial design and digital design. It became a huge success with many engineering students and now 50% are women.

The teachers at Architecture and Design could see the problem and the challenge of integrating math and physics with other subjects, technical as well as design subjects in the first year, so they came up with a solution – a new subject called tectonic – covering technical as well as design aspects of the first year curriculum. After years of discussions tectonic was launched as a pilot project three years ago. Tectonic is now an ordinary subject.

This paper will discuss how this change of curriculum could take place and which consequences and perspectives it has for other engineering subjects. Furthermore we will show the content of the tectonic course and the impact on the students' technical interests and their learning outcome.

The method used is analysing students' project reports during two years using among other analysis criteria three levels of reflections: common sense reflection, horizontal reflection and vertical reflection as well as interviews with students and teachers.

The conclusion is that the interest for technical subjects is higher than before when students entering the third semester. The learning outcome is better and especially the understanding of integration of technical subjects and architectural design subjects are in a higher level.

Keywords: Change curriculum - engineering education – technical subjects - problem based learning

1. Introduction

For many years there has been an ongoing discussion about the lack of students' interests in engineering educations. Several employers' organizations in Denmark are very concerned about students' choice of university education. (ATV 1996) During the last years the interests for humanities and social science have increased, and at the same time the interests for studying engineering have decreased. Many attempts have been made to strengthen the interests for technology, mathematics and science among young people starting in primary school and followed subsequently in grammar school or the like. A special attention has been focused on the gender aspects in engineering educations. This is not a new thought. (Belenky et al 1986). Since the eighties a special concern has been directed towards the problem of getting more women interested in engineering, which is not only a problem in Denmark (Kolmos 1989). Engineering in general is still dominated by male students, and some specializations have less than 5% women students e.g. electronics at Aalborg University. Different political initiatives directed towards more women into engineering had been made (CuWaT 1998),(HMSO 1995) as well as more general initiatives to get more engineering students at all. Reports had been made about new pedagogical approaches, the content of the different educations, the social aspects etc.(CuWAT 1998). But only few concrete attempts had been made to change curriculum or the content and organization of the education. As both of the authors have worked extensively with development and implementation of a new engineering education, Architecture&Design at Aalborg University, and they are both extremely interested in developing and improving the pedagogical approach and the content of the new education as well as the learning processes of their students, it seemed quite natural at the same time to try to develop a change of curriculum in one engineering education in their own university. One of the problems was the integration of the technical subjects with architecture and design subjects.

The objective of this paper therefore is to describe a pilot study on development and implementation of a new technical course, involving one small segment of a university educational program; the first year program called the Basis Year. The organizational background is presented in some detail, in order for the reader to be able to follow the development and implementation process. Thereafter, the project is analyzed in terms of the conditions that might have affected the implementation and how these relate to the overall goal for the Basis Year program. Finally, some future plans for extending the pilot are described, and insights are provided into this implementation, as well as ones in other contexts.

2. Organizational Background and Setting

The pilot project described in this paper takes place in what is referred to as the Basis Year program (i.e. freshman year) of the Architecture & Design (A&D) program, which is one of the 16 main educational programs offered within the Faculty of Engineering and Science at Aalborg University. In total about 700 students are enrolled in the Basis Year program. First, the structure of the program is described to provide a background for the pilot project. Aalborg University follows a problem-based project-oriented model of structuring its curricula. All education programs within Faculty of Engineering and Science at the university begin with the Basis Year program, which includes courses applicable to all students as well as courses specific to the particular education (e.g. A&D). The Architecture & Design (A&D) program was launched in 1997 within the Faculty of Engineering and Science at Aalborg

University for students wanting a five-year master's degree. Currently, there are 400 students enrolled in the master program (from 3. to 10. semester), and every year 90 - 140 new students begin in the first year program. Institute of Architecture & Design is responsible for the general administration and development of A&D master program as well as a majority of the teaching and advising of the students in the first year. Teachers from the institute of Architecture & Design is continuously discussing the content of the first year, how it fits to the overall idea of the profile of the A&D education. Several changes have been suggested for the first year e.g more integration of the technical subjects into the architecture and design subjects. But changing a big bureaucratic institution is not an easy task. A tendency is that technical courses have to be like they always have been.

But because of the increasing amount of A&D students in the first year (it is the biggest first year theme group; see fig. 1) it was possible to put a certain pressure on the head of the study board for making some changes bit by bit.

The Basis Year program has its own organization, which is separate from the organization that has responsibility for the second through fifth years of each educational program, and the head of the study board for the Basis Year has the overall responsibility of the study plans, the courses, the physical environments, the administrative support, the teachers' competencies and the outcome of the students' learning. The overall aim of the Basis Year is to introduce students to work in a scientific way with emphasis on methods, theories and models (AAU study guide, 2005). Another aim is to qualify students for continued studies within the Faculty of Engineering and Science and to train the students in claiming responsibility for their own learning. Each of these aims is addressed through a combination of problem-based project oriented group work and the coursework.

Every semester each group of students chose a project within the semester theme which has to be evaluated at a final exam. The time spent on the project work is about 50%. The other half of the time is spent on three types of courses: The first type is study unit courses (SE courses) which content general technical content for the specific semester e.g. mathematics and 3 D computer modeling. SE courses have their own exam. The second type is project unit courses (PE) courses which are mend directly to support the project work and they are normally reflected in the project. The third type of courses is free study activities (FS courses). These courses might have an exam, but some have an informal evaluation.

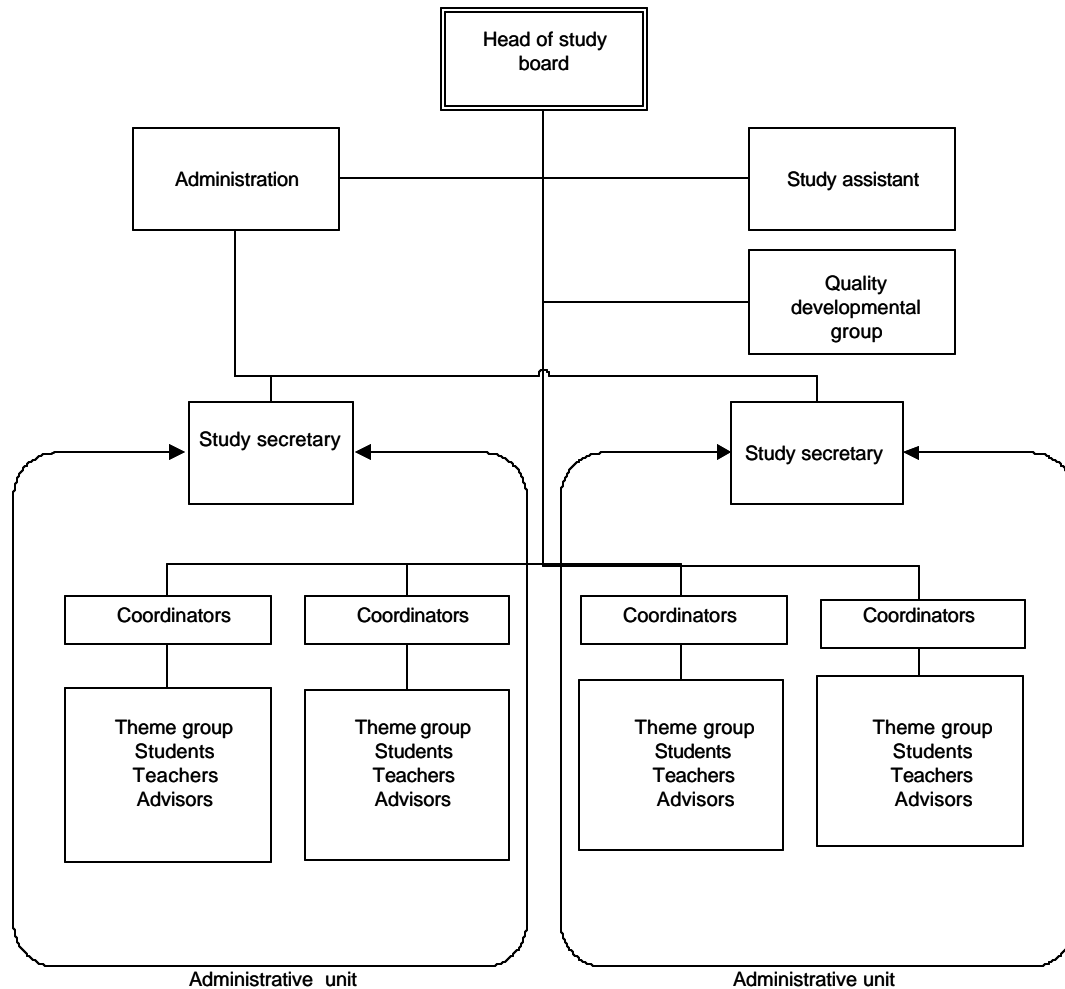


Figure 1. The figure illustrates the structure of the Faculty of Engineering and Science Basis Year. The figure is an example of how coordinators, teachers, advisors and students belong to a specific educational program – here called a theme group. One theme group is the A&D theme group. The size of the theme group can vary from about 140 students to 30.

The students work in project groups with 5 – 7 members. Each group chooses a project that conforms to the theme of their specific educational program, but the projects are under the formal authority of the Basis Year study board. A main advisor as well as a secondary advisor is allocated to each group in order to facilitate the project work, and there is also a coordinator for each semester that ensures the overall functioning of the students, coordination of their studies with the educational program as a whole, and the continuous development of the program. The advisors and the coordinators are selected by the individual master programs (e.g. A&D), but must be approved by the Basis Year study board. All of the coordinators of the Basis Year program meet once per month with members of the study board.

The teachers connected to the Basis year develop and describe examples of student projects and some of the courses within the frames of the study regulation. Everything has to be approved by the study board.

2.1. The need of changing content at the A&D Basis Year program

Four years ago the amount of A&D students starting on the Basis Year program had increased considerably in number which made it possible for the A&D teachers to negotiate with the Basis Year study board. The first important action was to make it possible for the A&D basis year coordinator, who was appointed among A&D teachers, could choose not only the main advisor, but also the secondary advisor. Those secondary advisors were appointed by a third institute, and their background did not match what the A&D program found necessary for their education. What was needed was a suitable combination of technical and design (architectural, industrial design, urban design, and digital design) backgrounds among the main - and secondary advisors. A second need was to change the technical courses so they were not stand alone courses. They should be designed so the students could see why and how they could use the courses in their project work. Normally students recognized those courses as a boring activity which they have to attend because they are finished with an exam. The motivation was lacking and the learning outcome could be questioned.

For a start A&D was allowed to appoint their secondary advisors. This was not an easy task because teachers from A&D and from more technical areas such as civil engineering, mechanical engineering, electronics etc. should learn to work together in an interdisciplinary setting with a common goal. This was a learning process for all advisors, but after 4 years we can say that it has become a success. Teachers from different areas have started to inspire each other. They have learned to use each others expertise towards a common understanding. Three years ago A&D was allowed to change the three courses in mechanics of materials, static and indoor climate/ventilation Those courses did not have the students' interests, because they could not use them, and they could not see that it might be beneficial for their work two or three years later. They passed their exams, but later in their study when they were going to use specific knowledge from the courses most of the students had to start from scratch. It took them long time to get the necessary understanding which they have to use in their project.

This was the background to design a course which had elements from the above mentioned subjects. The course should take the starting point in architectural cases and via those cases explain the technical aspects. The course tectonic was to be developed.

The following shows the courses for the A&D basis year in the second semester. The study unit courses have their own exams, and the project unit courses have to support used the students' projects. The free study activities can have an exam

First year AD courses in the spring semester

Study unit courses (SE-courses)

- ▶ [Mathematics 2A Class 1](#)
- ▶ [3D modelling on computers \(3D\)](#) Class A and B
- ▶ [3D exam project](#) (PDF) Class A and B
- ▶ [Tectonics](#) (TEK)

Free study activities (FS-courses)

- ▶ Form and colour (FF)
Workshop technique

Project unit courses (PE-courses)

- ▶ [Space, Man & Context analysis](#) (RMK)
- ▶ [Co-operation, Learning and project management](#) (SLP)
- ▶ [Methods and Communication of the field](#) (FMF)
- ▶ [Integrated design II](#) (ID2)
- ▶ [Sketching and analysis](#) (SA)

Other

- ▶ [Information retrieval](#)

3. Tectonics

After having discussed how to integrate several technical aspects within design/architectural areas, the teachers ended up with ideas based on tectonic (Frampton 1995). Originally the word tectonic derives from the word tekton, which in Greek means carpenter or builder. In general the term refers to an artisan working in all hard materials except metal. In the fifth century B.C. this meaning undergoes further evolution, from something specific and physical to a more generic notion of making, involving the idea of poesis. Later the role of tekton had lead to the emergence of the master builder or architekton (Borbein 1982.: “Tectonic becomes the art of joinings. “Art” here is to be understood as encompassing tekne, and therefore indicates tectonic as assemblage not only of building parts but also of objects, indeed of artworks in a narrow sense”. (Borbein 1982 p 9.) So the concept of tectonic was what could be the answer for integrating technical aspects with design and architectural aspects. First the challenge was to find teachers within the technical areas who would be open for this idea. Teachers who would like to work in an interdisciplinary way. One teacher from civil engineering was very interested and developed the course together with A&D teachers. It was very important that all technical subjects are connected to a design artifact or an architectural composition. So each lecture had a lot of examples as a starting point for the technical part of the lecture.

The objective and the content are shown beneath.

Tectonics (SE Course)

Weight:

2.0 ECTS

Objective:

To provide the student with theoretical and practical applicable knowledge regarding the interaction between design, construction and use of materials in the fields of architecture and design.

Content:

This course is a basic theoretical and practical applicable introduction to constructive principles of the design field and the applicability of different materials in design. Through practical exercises, the students train their abilities for transforming knowledge about the interplay between form, construction and material qualities into a physical model (architectonic concepts/architectonics’). On the basis of exemplifying cases, the static conditions are analysed and simple calculations are carried out.

Outline of the different lectures

1. Lecture (PHK)
I Introduction to the course. The structure of load-bearing constructions. The concept of force, equilibrium in tension and compression. Model laws.
2. Lecture
The parallelogram of forces. The concept of moment. Equilibrium of in plane forces. Static determinate versus static indeterminate structures.
3. Lecture
Support and reactions. Plane truss system. Determination of truss member forces. Equilibrium of truss sections.
4. Lecture
Plane beam systems. Continuous beams and cantilever beams. Determination of stresses in beams. Design based on moment curves.
5. Lecture
Stability by using shear walls. Arrangement of stable constructions.

6. Lecture
Details in connection with choice of Form, Construction and Material qualities in a physical model. Introduction to overall assignment/exam project.
7. Lecture
Columns and Frames. Euler's equation for columns. Designing columns and frames.
8. Lecture
Guest lecture in Tectonics and Architecture by Anne Beim (AB), The Royal Academy of Fine Arts School of Architecture, Copenhagen
9. Lecture
The arch. Designing arch constructions.
10. Lecture
Cable and membrane systems. Determination of forces in cables.

Evaluation:

There are two assignments connected to the course. One assignment just after the course: Structure of a spatial disc construction. (See description in the notes)

The other assignment is an overall assignment that gathers up the learned subject matters. The assignment is evaluated in the project groups together with evaluation of the semester project. The focus of the evaluation will be divided equally between understanding of the technical and the aesthetical aspects.

3.1. Course evaluation - Overall tectonic assignment

As the basis of the tectonic course evaluation, all groups must construct a tectonic design. Architects usually work in a model, which is a **representation** of the actual structure. In this case, the product *is* the actual structure, **the representation**, which means that detail and composition assume whole new meanings. This is full-scale architecture. This should not 'look like something', this 'is' something in itself. The assignment is introduced in the sixth lecture.

Every group chooses a 'toy model' (e.g. scale 1:18) of a vehicle. Use the vehicle to create a structure that says something about the vehicle and in which the vehicle forms part. It must not be obvious which vehicle that has been worked on, but the group must be able to explain how the chosen vehicle has been interpreted and transferred to the structure.

The assignment is to create a pedestal. There must be a model of a vehicle on the pedestal. Every group has different x, y and z coordinates that refer to the centre of the bottom of the vehicle.

Nothing in the tectonic design – not even the model of the vehicle should be able to be removed without the design losing its meaning and collapsing. The model of the vehicle must therefore be an active component in the construction, so that the design does not exist without the construction and vice versa. The construction must be independent, which means that it is forbidden to drill, glue or other things in/on/to the table.

The construction must be theoretically stable. It is required to take the equilibrium conditions into account. In practice, it must be stable and of strength that matches its practical placement in its context.

For making the construction, the following materials may be used:

- Cables (string, wire or similar)
- Bars, columns (wood, metal or similar)
- Beams, sheets and discs (cardboard, wood, metal, glass)

Only three different materials must be used and it is important to be precise, which means using the materials for what they are best suited for.

There are no limitations as of how far into the space you may extend the tectonic design, but you must be able to transport the tectonic structure from your group room (or workshop) to room 302.

Remember the tripartition of form, technique and materials when you are designing, because it is possible for all three elements to be taken into account when the design undergoes criticism. Form, meaning, choice of materials, composition of materials, color, texture, smell, joint details, execution, precision, interplay between detail and whole, interplay between vehicle and construction, and interaction with the space are all issues that can be taken into account when the design undergoes criticism.

The evaluation itself takes place as a conversation where you will get the chance to explain how you have been working on the design of the structure, and where clarifying and elaborating questions will be asked (see below). You should not prepare a presentation.

Tectonic-themes/questions

- 1) Which overall idea is communicated through the tectonic design?
- 2) Explain the structure on the basis of constructive knowledge/ aesthetic idea.
- 3) How do you understand the tectonic concept and how is that reflected in your structure?
- 4) On the basis of which requirements have you chosen and worked up your materials?
- 5) How are details worked up and why?
- 6) Give an account of how your structure complies with equilibrium equations.
- 7) Sketch a free-hand object diagram of your structure
- 8) With point of departure in the equilibrium equations and the free-hand object diagram, show that your structure is stable.
- 9) Show the shear force determination for the structure.
- 10) Give an account of the coherence between the size of your structure and its dimensions with point of departure in the concept of tension and the modelling rules.

Group number	X (mm)	Y (mm)	Z (mm)
227	0	0	400
229	200	0	400
235	400	0	400
237	0	200	400
341	200	200	400
343	400	200	400
345	400	400	400
347	0	0	200
350	200	200	200

351	200	200	600
354	0	0	400
355	200	200	400
358	-200	-200	400
359	-200	-200	0

All groups presented very good results and demonstrated an understanding of the different topics which is far above earlier experiences within the 'old' courses. The students are very interested in the course topics, they can see the usefulness of the different technical areas, and many are so motivated that they ask for more material to read themselves, because they have to establish more knowledge, which should be used in their project. Interviewing the teachers/advisors they agree that the students' motivation for integrate tectonics with design has become a big success. And students who have had the tectonics course are better equipped with this specific knowledge at the second semester than 7th semester students with the 'old' course.

3. Perspectives

The perspectives are a better understanding of the connection of the course and the field of architecture and design. Furthermore the project exam has change character so it actually reflects the interaction of architecture and design and different technical aspects.

Former the technical study unit courses with their connected exams became implicit the centre of the identity of the first year because students could not immediately use the knowledge and relate to architecture and design.

Tectonics takes departure in architectural cases in order to explain the technical subjects and by this approach establish equality among architecture- and design- knowledge and technical knowledge. So now this study unit course provides students with an extended reference connected to architectural design and the related tectonic elements. Students experience this relation and are much more conscious according form, static, construction and tactility.

Students are evaluated as groups in their main project, but they are assessed individually. The overall tectonic assignment is part of the examination. A new element is that the 3D study unit course is evaluated as part of the exam. The tectonic assignment is to make a real model. The 3 D assignment is to make the same model in 3 D. This illustrates that the same assignment contains many disciplines which is another way to be aware of the many aspects of studying engineering with specialization within architecture and design.

All teachers connected to the courses and the advisors connected to the project group take part in the examination. The teachers agree that this new approach has given the projects a much higher quality. Before projects were either too technical or too architectural and very seldom projects reflected any in teraction between the different knowledge areas. This new approach has had a great impact of almost all students' apprehension of their future study, but also the teachers see new possibilities. The next step change will be to work with the course in mathematics in the same way as tectonic.

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Note: Tectonic Assignment

The structure of spatial stable disc constructions

An at least three-storied model of a spatial stable disc construction with and an optional ground-plan must be worked out of cardboard (wooden lists can be added). The construction can be understood as either a building, a piece of furniture or as an optional sculpture.

The model must be built on a rigid foundation consisting of chipboard or something equivalent in order to compensate for the insignificant dead load of the model in regard to the actual construction, and assembling is carried out by using glue. The bottom plate is ca. A4 sized and each 'floor' is ca. 5-6 cm high.

Forces from the vertical loads on the construction are insignificant in this assignment. The essential point is to create a spatial stable construction against the horizontal forces from random directions. The horizontal forces attack on the edge of the horizontal discs and these horizontal forces must be led downwards to the rigid bottom plate through the disc construction. The construction must come across as being rigid in connection with these horizontal forces. It should be attempted to make a construction, which to the fullest exploit the specific expressional modes of disc constructions as well as the constructive possibilities. Use as low a number of discs as possible.

The assignment has to be carried out by groups of students.

Objective:

It is the objective of this assignment that the students gain an understanding of the principles which form the basis of spatial stable constructions.

Model materials:

The model materials should be purchased before Friday. The cardboard needs to be of a fairly thin quality and not too heavy. The cardboard discs must be elastic and must be able to be bent and twisted transversely to the disc plane. The glue preferably stays elastic like e.g. contact glue. Wooden lists may only form part of the model as 'articulated column structures' between the individual horizontal discs.

Exam:

The disc model **must** be brought along to the evaluation, where the individual students must explain how random horizontal and vertical forces on the horizontal discs are transferred to the rigid bottom plate (the foundation).

When you put horizontal pressure on the edge of the horizontal discs, spatial stable cardboard models will feel rigid and unyielding. Spatial instable cardboard models on the other hand feel yielding and non-rigid, which tells us that the shape is wrong for a disc construction.

