

## **Increase the ability of taking fast design decisions based on hand-calculations founded in mathematic analysis**

### **Abstract**

This project aims to increase the activity of the students in an advanced course in solid mechanics. The ambition is to connect the knowledge in mathematic analyse with a feeling of how to use this analyse in the context of a real problem in order to make estimations without using a computer.

The focus of the teaching during the course is going to be changed to more a student active one. The intention is to include ideas from problem based learning or learning using cases. The actual problems or cases should be chosen close to the everyday life of the students so they can relate to the problem and easier get a feeling of the consequences of their analysis.

One part of the examination of the course is going to take place in groups of approximately six students, where the students act as members of a board. They have to prepare one item each of the agenda, then they are going to convince the board and finally the whole board is responsible for the decision. The items of the agenda could be a design proposal to analyse or an already analysed problem to consider. In the first case the student has to make a decision like: Can the construction be designed like this and which are the critical points? In the second case the decision might be: Is this analysis done correctly? The teacher acts as a listener at the board meeting and examines both the individual decisions and the way the student motivates his decision for the rest of the board.

### **Keywords**

Higher Education, Classroom Research, Instructional Innovation, Engineering Education, Active Learning, Situation Tests, Decision Making Skills

**Improving students' ability to make quick design decisions based on hand calculations based on mathematic analysis.**

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## Abstract

This project aims to help students acquire the ability to apply factual knowledge from mathematic analyses to real problems. Students are called upon to make estimations and decisions without the use of a computer.

One part of the course examination takes place in groups of approximately six students, where the students act as members of a board. They have an hour to consider an item from a simulated meeting agenda, analyse it briefly, present their positions and reach a common decision. Two teachers act as observers at the board meeting and consider both the individual decisions and the way the students argue for the rest of the board.

*Keywords:* Engineering Education, Active Learning, Situation Tests, Decision Making Skills

## Introduction

### *Rationale for change*

The reason for making changes in how to teach the actual course was student critique of the course as expressed in course evaluations. The students were not so critical of the curriculum in itself, but rather in its presentation. They found it hard to see how the content of the course could be applied in the real world. The course is based on advanced mathematical analysis and computers were hardly used at all. Students felt passive in the traditional teaching situation with a teacher standing talking and writing at the black board. The examination was a traditional written exam.

There were basically two options open to us. We could change the course to become more computerised or we could keep the emphasis on hand calculations with a better motivation. We chose the second alternative and decided to emphasize the ability to make fast design decisions based on hand calculations grounded in mathematic analysis.

We wanted to activate the students during the course, to give them the opportunity to practise defending their positions, to learn how to make decisions on their feet, and to introduce them to situations similar to what they can expect when they start their working careers. This is something students often ask for in surveys (Utvärderingsenheten vid Lund University, 2005).

### *Review of relevant literature*

It is hard to find anything really relevant in the literature in this field. Some of the thoughts, however, are in the same directions as presented in French (1999). The subject there differs; it is more design and not so much mathematical considerations.

### *Questions*

The most critical question in order to get a successful result is to explain the ideas for the students, motivate them and to convince them to give it a try.

*Importance of the project to me and why*

It is important for me to give a good course. By this I mean a course that attracts students and gives them opportunities to learn something relevant. I want the students' learning process to be active; to mesh with Kolb's circle of experiential learning, see Figure 1.

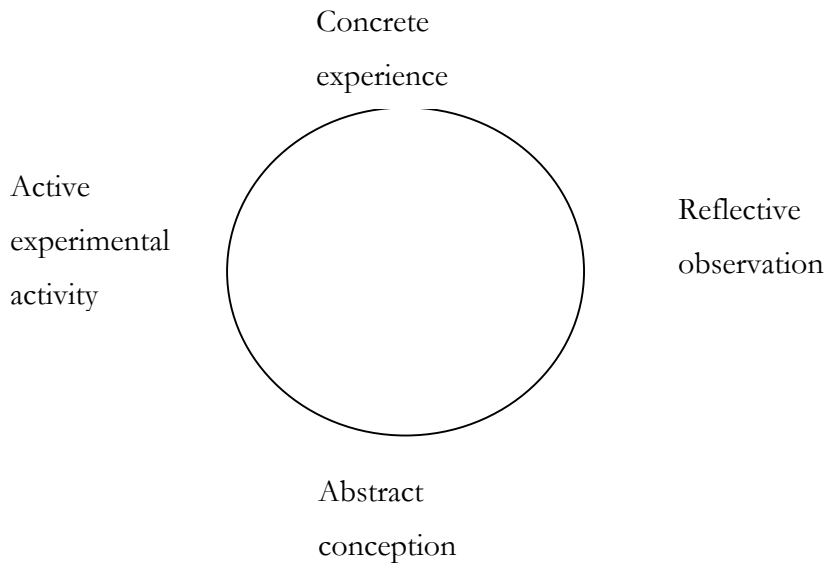


Fig. 1. Kolb's circle, Kolb (1984). The idea is to rotate clockwise through different stages in the learning process, i.e. do an active experimental activity, experience, do a reflective observation and make an abstract conception.

In the course, examples were chosen from the daily lives of the student in order to ensure that the students have experiences to refer back to. Reflective observations come in during the board meetings and abstract conceptions during the mathematical analysis. Some smaller experiments are included in the course as well as a study visit to enhance concrete experience.

Efforts are also made to align all parts of the course, a so-called constructive alignment as discussed in Biggs (2003). The critical aspect is to carefully consider through the course content.

## Method

### Students

The course is called “Dimensioning problems” and it is an advanced course in Solid Mechanics. The students study on the program for mechanical engineers or physical engineers and they are on their 3:th or 4:th year. They have already taken the prerequisite courses in mathematics, mechanics, and solid mechanics and their knowledge in these subjects builds a foundation for the elective course “Dimensioning problems” which starts at a quite high level of abstraction. There are about 15-30 students taking the course and between 25 and 35% of them are women. The course is given as mixture of lectures and different kinds of problem solving exercises.

### Innovations

The course was given three times during the course of this project. The first time, starting in January 2003, was too close to the Council’s announcement of its funding decisions to have time to implement any substantial changes in the course. Instead, we collected as much background data as possible during this course, including surveys to capture student opinion of the course as it was taught as well as discussions with students and colleagues about the course curriculum and our teaching approach for the different sections in the course.

The second time the course was given, starting in January 2004, we made changes in the structure of the course. Long, detailed presentations of mathematical derivations were abandoned in favour of overviews. Those students who are truly interested in such details, can always look them up in the course literature. The assignments were redesigned in order to include subjects closer to the students’ everyday life and rewritten so as to include an element of decision-making. Also, a field trip to a real industrial plant was introduced in order to motivate the students. During this visit the students got an opportunity to study the manufacturing processes at the company and meet a real engineer. The engineer shared their insights about how professional life as an engineer might turn out for the students.

In order to test the idea of board meeting, the students got a case to work on toward the end of the course. In order to solve their cases, groups of six students were called upon to combine learning from different parts of the course, with a teacher as a passive supervisor. The result from the case was then evaluated.

During the autumn of 2004 the project group was expanded to include one more teacher, (Göran Wihlborg), a PhD- student (Magnus Fredriksson), and a student, David Lönn. This group met and discussed the project's basic concept, as well as planning for a full-scale implementation of the board meeting scenarios in course examination. Suitable problems for the board meetings were also discussed.

Finally, the third time the course was given, starting in January 2005, the examination method with board meetings was implemented. The method was presented to the students by explaining the rules and trying it out first in the classroom under the supervision of two teachers.

First, students received the following written instructions about how to allocate responsibilities within the group during the exercise:

The *chairman* was responsible for:

- *Leading the meeting*
- *Distribute the opportunity to talk among the board members*
- *Keeping an eye on the clock*

The *secretary* was responsible for:

- *Writing notes during the meeting*
- *Writing down the decision on the prepared protocol*

The remaining *members of the board* were responsible for:

- *Contributing in a constructive manner to the discussion*
- *If the need arose, using the black board to clarify an analysis*
- *Signing the protocol*

The different roles are decided in a lottery immediately prior to the meeting. Students are allowed access to literature. The meeting takes 60 minutes and the board has to be concluded

with a decision written by the secretary in a prepared protocol. All the board members are required sign this protocol. Two teachers are present in the room and they take notes on individual student contributions to the process. Up till now, a central criterion for passing this exam is active participation. If the discussion really gets off track, the teachers are allowed to intervene with a short comment to get things back on the road again.



Figure 2. A board in action.

The room where the meeting takes place is furnished so as to make it as similar to a real meeting room as possible (see Figure 2). Agendas, note pads, and pencils as well as coffee and buns for the obligatory coffee break are on the table to give an authentic touch of the meeting.

The problems brought up during the meeting are problems that require knowledge from more than one part of the course in order to be solved. The students are also expected to combine knowledge from different fields. A typical agenda is given in the appendix.



If the students succeed with their course assignments and pass the “board meeting” exercise during the course they receive a final mark of “3”. If they are interested in attaining the higher marks of “4” or “5” they also have to take a written exam that includes multiple-choice questions and traditional mathematical calculations.

## Procedures

The course was evaluated with the standard institutional protocol for course evaluation, CEQ – Course Experience Questionnaire, which is used for all courses given at Lund Institute of Technology. The students answer a 30-question survey and the results are compiled centrally and discussed with a student representative. Reports from these discussions are then written by both of the teacher and the student and sent to the central administration. All results are made available on the homepage for LTH board meetings.

As a complement to CEQ, smaller evaluations are done during the course starting from the very beginning. The students are asked their reasons for taking the course and what their expectations are. Later, they are asked how they think their learning proceeded and their opinion of different elements of the course. Answers are collected in written form and the results are collated and presented to the students as soon as possible (often the day after). Adaptation of the way of teaching is based on these evaluations.

The critical question about motivating the students to participate actively in this new version of the course that was mentioned earlier in the Introduction turned out to be a much smaller problem than expected. The students liked to try something new and just wanted to know all the rules in order to feel secure with the new procedures.

## Results

The students are more pleased with the course now than before the revision. This can be seen in the evaluation results in the Appendix. The evaluations should be read keeping the number of student each year in mind.

	2003	2004	2005
Number of students	15	12	28

It is much easier to please 12-15 students than 28. The main criticism from 2005 course had to do with the students' perception that they did not get enough feedback for the assignment. The teachers involved in the course agree. There was not enough time for feedback due to an excessive workload. This does not bother us teachers that much, since it is immensely satisfying that the course became so popular with the students that they began recommending it to their friends.

I asked the 28 students that took the course in 2005 to write one word each that describes their experience of the board meeting. A list with their answers is found below (some of them wrote more than one word):

### One word describing my experience of the board meeting

- *Interesting (4)*
- *Nice (5)*
- *Instructive (2)*
- *Useful (6)*
- *Change the procedure*
- *No structure*
- *New thought*
- *Mesy*
- *Giving*
- *Instructive (chicken farm)*
- *Not practised*
- *Complement*
- *Experience*
- *Good-humoured*
- *Innovative*
- *Rising thoughts*
- *Fun but short*

## Discussion

### Analysis

The primary reason why this project worked so well is the good cooperation with the students. It is one thing to have an idea and a much bigger task to implement the idea into a course. The persistency and engagement of the involved teachers were also important for the positive results.

### Implications

The project results imply that the course can be improved for both for the students and the teachers. We expect the students to be better prepared for careers as civil engineers and the teachers experience a variation in teaching methods. The reputation of the course improved and we expect more students will chose to take it. Furthermore, we expect to see a positive ripple effect on other courses at our division.

### Conclusions

The project will continue. We need to develop new tasks and improve the examination process. This year there we presented the students with three assignments and one board meeting. We are considering including two assignments and two board meetings in order to be able to provide more feedback to the students. The students get feedback in the group process and the teachers can concentrate on commenting on the two assignments.

There has also been criticism of the course literature. The written material really does need to be looked over, corrected and modernised.

Results from the project are going to be presented at the “Pedagogisk Inspirationskonferens” in Lund in the end of May and also at the Council’s “Pedagogisk Utvecklingskonferens” in Karlstad in November 2005.

## Appendix

1. Example of agendas (in Swedish).
2. Course evaluations from 2003, 2004, 2005 (in Swedish).

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The project is financed by a grant from the Council for the Renewal of Higher Education. The author wants to thank Ass. Prof. Göran Wihlborg, Ph-D student Magnus Fredriksson, and M.Sc. David Lönn for their cooperation.

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