Benchmarking of Teaching Practises 2001

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Abstract
The report describes the compulsory courses of three engineering programs: Mechanical Engineering at Chalmers, Applied Physics and Electrical Engineering at LiTH and Vehicle Engineering at KTH. Interviews were conducted with the responsible teachers in 2001, which was before any major changes were implemented as a result of the CDIO project. The courses are described with focus on objectives, teaching, assessment and evaluation.

A majority of courses are designed in a uniform way. They are delivered through lectures, recitals and laboratory work. Practically all courses are have a final exam. Most courses have other required coursework, such as assignments and projects, but these are seldom graded. Objectives are mainly expressed in terms of course content. There were few explicit objectives regarding generic skills such as teamwork and communication skills. Objectives were only rarely classified with a taxonomy. All courses surveyed are evaluated using student questionnaires at the end of the course, focussing on students' perception of teaching and course organisation.

Many of these "traditional" courses show examples of pedagogical innovation within the traditional course model. A few courses are designed in a completely different way, for instance using PBL. The survey shows some significant differences between the universities.

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1. Introduction

The CDIO program for reforming the engineering education is a focussed initiative to improve undergraduate engineering education. The four participating engineering programs are Aeronautics and Astronautics at MIT, Mechanical Engineering at Chalmers, Applied Physics and Electrical Engineering at LiTH and Vehicle Engineering at KTH.

Within the CDIO program there are four different themes, Curriculum, Teaching & Learning, Assessment & Evaluation, and Workshop. The first theme, Curriculum, is about changing “what we teach” whereas the others are about consequent changes and improvements to “how we teach”.

As a starting point for the change process a survey of current teaching practises was undertaken at the four universities participating in the CDIO effort. The idea/approach of these surveys was to find out the teaching status of our programs through interviews of teachers.

The MIT survey was different from the Swedish surveys because it interprets existing data from other sources. It is published by Diane Soderholm in a separate document.

2. Theory

2.1 Objectives

Figure 1. Objectives.

The target for the education program is communicated through learning objectives. The CDIO syllabus contains a complete set of learning objectives divided into four sections:

1. Technical knowledge and reasoning
2. Personal and professional skills and attributes
3. Interpersonal skills: teamwork and communication
4. Conceiving, designing, implementing and operating systems in the enterprise and societal contexts

Objectives should be active and student-centered, which means that they are expressed in terms of what the students should be able to *perform* as a result of learning. The resulting performance must be observable. Objectives that describe internal states that cannot be observed, such as “understand” or “be familiar with”, should be avoided.

> *“The goal of most teachers would be that their students ‘understand’ what they teach them. However, what is meant by ‘understanding’ is not always very clear. [] Clarify different levels of understanding and convert them to curriculum objectives, as appropriate to the content and level of the unit.”* (Biggs 1999)

Objectives are classified using a taxonomy of learning objectives, for example Bloom’s taxonomy (Bloom 1956).

Table 1. Bloom’s taxonomy of educational objectives (1956).

Level of objective	Active verbs
Evaluation	assess, decide, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support, conclude, compare, summarize
Synthesis	combine, integrate, modify, rearrange, substitute, plan, create, design, invent, what if?, compose, formulate, prepare, generalize, rewrite
Analysis	analyze, separate, order, explain, connect, classify, arrange, divide, compare, select, explain, infer
Application	apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover
Comprehension	summarize, describe, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend
Knowledge	list, define, tell, describe, identify, show, label, collect, examine, tabulate, quote, name, who, when, where

2.2 Assessment

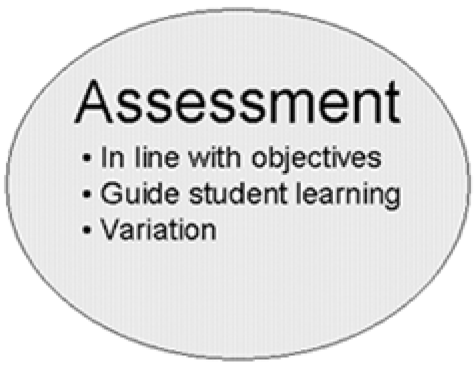

Figure 2. Assessment.

Assessment is the most important guide students have to the learning objectives. Therefore it is very important that assessment is in line with the learning objectives that we set out to fulfill.

> *"The objectives contain criteria for the desired learnings, which the assessment tasks are designed to address, thus linking objectives and assessment. Such criterion-referenced assessment steers students' attention to what is to be learned, while their performance tells us how well they have learned it, and how effective our teaching has been."* (Biggs)

The alignment between assessment and objectives is absolutely necessary. If there is any discrepancy between assessment and learning objectives, the result is that the curriculum *as defined by the assessment* will override the (official) objectives.

> *It is not the curriculum that shapes assessment, but assessment which shapes the curriculum.* (Brown & Knight 1994)

In addition to setting the target for students' performance, assessment is a powerful tool to guide and support student learning. One example is that continuous assessment activities will help students getting started early in the course.

Potential pedagogical effects of well-designed assessment:
- Generate appropriate learning activity (what kind of work they do)
- Generate time on task (how much work they do)
- Help students plan their work, timing (when they work)
- Provide feedback to guide learning
- Create motivation

The program as a whole needs a good variation of assessment methods. Students need to both practise and demonstrate the application of their knowledge in many ways. At least some of the assessment situations should be relevant for professional contexts.

> *A broad and balanced curriculum demands a broad and balanced assessment system.* (Brown & Knight 1994)

2.3 Teaching

Teaching is what lies between the setting of objectives and the assessment. The role of teaching is to facilitate learning, so students can reach the objectives.
Thus, teaching must also be in line with objectives. Perhaps the alignment of objectives and teaching is a little bit less crucial than that between objectives and assessment, since – bluntly put – "*students can escape bad teaching; they cannot escape bad assessment*" (Brown & Knight 1994).

Some characteristics of good teaching have been identified by Biggs (adapted from Gibbs 1992):

1. *Motivational context*
   Deep learning is more likely when students' motivation is intrinsic and when the student experiences a need to know something […] in order to carry out tasks which matter to them.

2. *Learner activity*
   Students need to be active rather than passive. Deep learning is associated with doing. If the learner is actively involved, then more connections will be made both with past learning and between new concepts. Doing is not sufficient for learning, however. Learning activity must be planned, reflected upon and processed, and related to abstract conceptions.

3. *Interaction with others*
   It is often easier to negociate meaning and to manipulate ideas with others than alone. Interaction can take many forms […].

4. *Well-structured knowledge base*
   Without existing concepts it is impossible to make sense of new concepts. The structure of knowledge is more visible to and more useful to students where it is clearly displayed, where content is taught in integrated wholes, rather than in small separate pieces, and where knowledge is required to be related to other knowledge rather than learned in isolation.

Figure 3. Teaching.

2.4 Evaluation

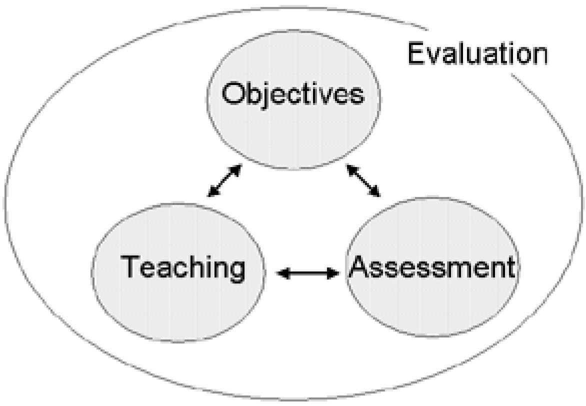

Figure 4. Evaluation is our tool to help us develop and improve teaching, assessment and objectives, and the relations between them.

A mature perception of evaluation suggests:

> ”*Evaluation is best conceptualised not as something that is done to teachers […], but as something that is done by teachers for the benefit of their professional competence and their students’ understanding.*” (Ramsden 1992)

It is also important to note that evaluation should not only focus on monitoring the quality of teaching, as perceived by the students. Evaluation should address all parts of the pedagogical model; teaching, assessment and objectives, as well as the relations between them.

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3. Method

The survey used interviews as method. Interviews were conducted in 2001 with all teachers responsible for current *compulsory* courses at the Vehicle Engineering program at KTH, Mechanical Engineering at Chalmers and Applied Physics and Electrical Engineering at LiTH.

Note that the courses surveyed do not perfectly reflect a student's path through the program. What we see here are rather like snapshots of what the respective years were like in 2001. It is important to have in mind that this benchmarking describes the courses before any major changes were implemented as a result of the CDIO project.

The same questionnaire was used in all three universities. See Table 1 for the questionnaire in English, or Appendix A for the questionnaire in Swedish. The questions were about the course and its organization, objectives, pedagogical model, interaction, assessment and evaluation.

The interviewers at the three universities have rather different backgrounds and different roles at each university. One is an associate professor, one is a student councelor, and one is a pedagogy consultant. We believe that our differences have influenced what questions we emphasize and also how we interpret the answers.

The interviews lasted between 1 and 2 hours each. At the end of the each interview the teacher had the opportunity to give any other information they thought relevant about the course. Most teachers have been very positive to the interviews and have been giving a lot of information about their courses. Many teachers have also said that the interviews have given them an opportunity to reflect about different aspects of their course.

Table 1. Questionnaire used at KTH, LiTH and Chalmers

Concept	**Question posed**
Aim / Objectives	
Pedagogical approach	Is there an explicit pedagogical model?
Teaching techniques	Lectures
(Kursens upplägg)	Recitations
	Laboratory work
	Assignments
	Hands-on activities
	Other
	and relation between activities
Use of technology	Computers
	Web
	Other
Diagnostics	Test of previous knowledge
Motivation	How do you motivate the students?
Interaction	Student - teacher
	Student - student
	Student - other
Assessment	Assesment methods
	Learning outcomes?
	Taxonomies?
Course evaluation	What is the purpose of the evaluation?
	Which are the main questions?

4. Joint results at Chalmers, KTH and LiTH

4.1 Objectives

We find that objectives mainly reflect section 1 of the CDIO syllabus (Technical knowledge and reasoning). A minority of courses have any explicit objectives regarding the skills covered in sections 2-4. It is clear however, that the course design often reflects an ambition to teach these skills, but this aim is not made explicit in the course objectives (or assessment).

Only in a minority of courses are the objectives formulated as intended learning outcomes (what the student can do as a result of learning). Objectives are commonly formulated as "students should be familiar with / gain understanding of / have knowledge about x, y and z (the content)". It would seldom be possible to determine whether the objectives have been attained or not, as the level of familiarity, understanding or knowledge required is not defined in terms of performance that can be observed. A small number of teachers have used a taxonomy to classify the objectives.

Generally, though, we see a good basis for rewriting/developing the present objectives into measurable learning outcomes.

We have the impression that objectives are not really used by the teacher to determine teaching and assessment. It is considered more as a piece of text that is produced for the official course documentation.

4.2 Teaching

Pedagogical model
We see an extraordinary uniformity of course design and delivery. The pedagogical model of a majority of the compulsory courses is referred to as "the traditional model". The typical teaching activities are lectures, recitals (often a teacher who demonstrates problem-solving), and laboratory work (including programming tasks).

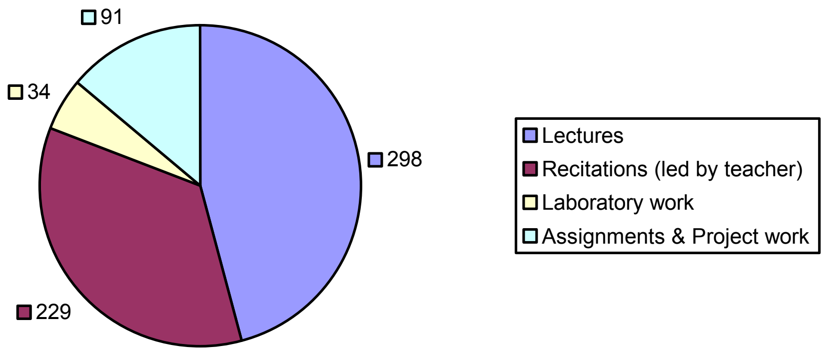

Figure 5. Different teaching activities (hours) offered at Chalmers, per academic year (40 credits).

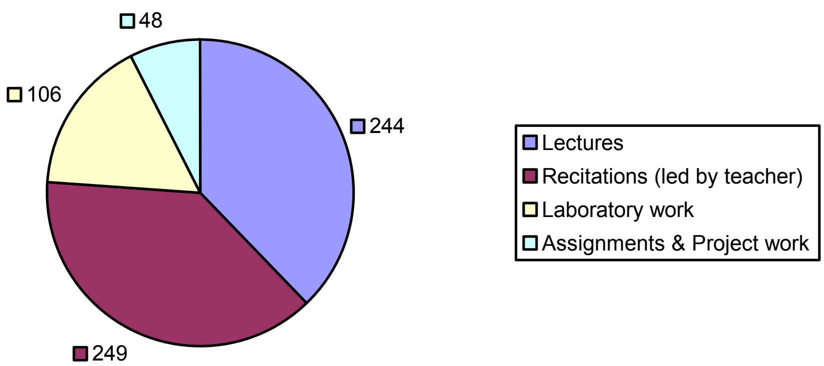

Figure 6. Different teaching activities (hours) offered at LiTH, per academic year (40 credits).

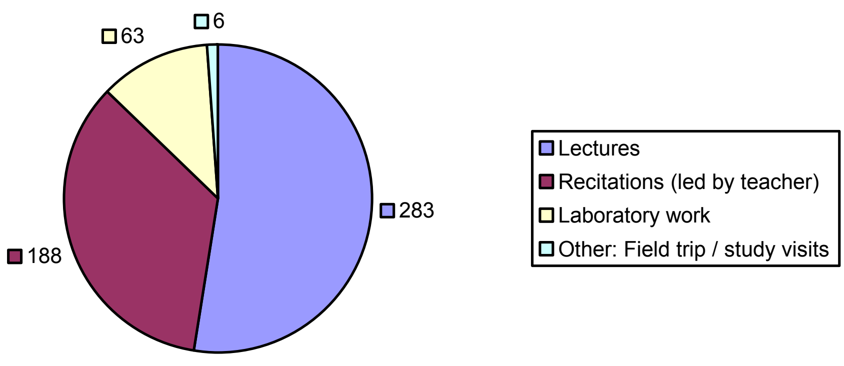

Figure 7. Different teaching activities (hours) offered at KTH, per academic year (40 credits).

Relations between different activities
In most of the courses the relations between the activities in the course are what could be described as bottom-up. The lecture presents terminology, concepts and theory of the subject, after that the lessons/recitals deal with problem-solving, using the material that has been presented at the lecture. Finally, in laboratory work the students work with construction or experiments.

> Top-down approach, a good example from LiTH
>
> In one course at LiTH the teacher has a different order between the activities in the course. The students start with the laboratory work, then they have lessons and finally they have lectures at the subject. The main goal with this way to present the subject is to get the students become more curious so they get motivated through the whole course.

Diagnostics
We asked if teachers did any diagnostic testing to see whether the students had the knowledge necessary to succeed in the present course. In only a small minority of the courses the teacher did any diagnostic to check students previous knowledge. The check was always through discussion in class. We believe that many students would hesitate to openly admit that they lack the necessary knowledge, and just asking in class may not always produce true results.

> Recap of an earlier course, a good example from LiTH
>
> In one course in year three at LiTH the teacher knew from earlier experience that the students did not have the previous knowledge they were expected to have. Therefor the teacher uses one lecture in the course to repeat the most important parts from a course in year one, just to give the students the knowledge they are supposed to have so they have the possibility to be successful in the current course.

4.3 Assessment

The final exam of approximately 4 hours is the dominating assessment method.

In addition to the final exam, most courses also contain required course work, such as assignments and projects. These assignments and reports are almost never graded in themselves, however it is common that they give bonus points for the exam.

A minority of courses have one or more smaller test during the course. These are often voluntary and give bonus points for the exam.

Assessment for understanding, a good example from KTH

One course at KTH has a final exam, which differs from the traditional exam in two ways. The first is that the exam deals with problems in a previously unseen context, an area which has not been covered in the course. Students are required to apply their knowledge to this new area. The second is that students are allowed to use anything for help, except contact with other people.
Note that the teaching of the course is fairly similar to other courses, it is mainly the assessment that is different.

Some observations can be made: This exam measures high-level objectives, which are relevant for a graduate. It is not possible to pass the exam by regurgitating what has been presented in class, or by learning the typical problems from previous exams. More appropriate learning activity is generated (studying for understanding rather than rote learning).
Finally, note that this innovation is made within the limitations of the traditional final exam. It is not the assessment *method* that is different, but what the teacher sets out to measure.

LiTH different from KTH and Chalmers
We found a clear difference regarding assessment at KTH/Chalmers vs LiTH. At KTH and Chalmers *all* the compulsory courses have a traditional written exam. Most courses also have other compulsory parts such as assignments, which are, however, not graded. At LiTH the picture is different, as 25% of the courses do not have a traditional written exam. Assessment in these courses is done through assignments and project work, and these courses are generally ungraded (pass/fail).

We believe that this difference reflects the different traditions at the institutions. KTH and Chalmers are both around 175 years old. LiTH, on the other hand, was founded only some 30 years ago, in a spirit of modern pedagogical methods, with extensive use of PBL.

4.4 Evaluation

All courses surveyed are evaluated using student questionnaires at the end of the course. Other methods include meetings with student representatives during the course or informal discussion in class. The focus is on students' perception of teaching and of course organisation. Objectives and assessment is not focussed on.

Although course evaluation is mandatory both at KTH, Chalmers and Linköping, when asked about the purpose of evaluation, teachers never refer to being under an obligation. Instead they express a wish to improve as teachers and to improve their courses.

As many teachers have observed, collecting data isn't the same thing as improving teaching. Many teachers express confusion on how to use the information to develop the course. An important driving force for the teachers is to minimize the amount of complaint and critisism, but as some teachers observe, this strategy provides little guidance. Having the symptoms of a possible problem pointed out to you doesn't mean that you are able to identify, analyze and solve it. The teacher must be able to make correct interpretation of the evidence, then plan and execute changes accordingly.

> Well-documented course evaluation, a good example from KTH
>
> One teacher showed particularly comprehensive documentation of the course evaluation and development process. The protocol contains the study results, a compilation of results from questionnaires, minutes from a discussion among the teaching team, and minutes from a group discussion with students. The group discussion was conducted with the help of a checklist, which is also included in the documentation. The views and experiences from all these sources are summarized, and they result in a prioritized list of planned measures to improve the course.
>
> The documentation makes it possible to follow up on changes over time. It is also easier to run the development process with continuity, even though there are always new students and perhaps also a few new teachers the following year.

5 Acknowledgements

We would like to express our warmest thanks to all teachers who took the time to discuss their courses with us, and to Khalid El Gaidi who wrote the questionnaire and provided valuable input during discussions.

Appendix A. Questionnaire in Swedish

Kursnamn/poäng:
Mål:
Syfte:
Diagnostik?
Kursens pedagogiska modell:
Finns det en uttalad pedagogisk modell för kursen? Vilken?
Kursens upplägg:
Antal föreläsningar:
Labbar:
Övningar
Relationen mellan olika aktiviteter:
Förekommer det någon form av hands-on aktivitet?
Teknologianvändning:
Datorer
Webb
Annat
Interaktion
Student-lärare
Student-student
Student -andra
Motivation
Hur motiverar Du kursen för studenterna?
Kursinformation för studenter
Kurs PM (finns kopia?)
Examination
Utfall av lärandet(learning outcomes)?
Finns det explicita kunskapstaxonomier?
Utvärdering av kursen
Vilka är utvärderingens viktigaste frågor?(Finns kopia?)
Till vilket ändamål görs utvärderingen?
Annat?

Appendix B1. Report from KTH.

Benchmarking of Teaching Practices in the Vehicle Engineering Program at KTH

Khalid El Gaidi and Kristina Edström
KTH Learning Lab

Abstract

A survey of *current teaching practises* in the Vehicle Engineering program at KTH has been undertaken as a starting point for development to improve student learning. A survey comprising of in total 23 courses was undertaken. Out of the 23 courses, 20 are all compulsory courses in the first three years of the Vehicle Engineering program, and 3 are a sample of specialisation courses from the later part of the program. The teachers responsible for the courses were interviewed during the period March - October 2001.

It is concluded that the pedagogical model used in practically all the courses surveyed is what is referred to as "the traditional model" at KTH. This means lectures, recitals and laboratories, finished by a final exam.

Introduction

The CDIO program for engineering education reform aims to develop engineering education. The project aim is to develop teaching methods that are based on active learning, promote concrete and hands-on learning, and provide better feedback from student to teacher and from teacher to student. An overall requirement is that teaching, assessment and evaluation should be in line with intended learning outcomes.

This survey of current teaching practises has been undertaken as a starting point for the development at KTH.

Method

The survey comprises 20 courses, all the compulsory courses in the first three years of the Vehicle Engineering program, in total 103 credits which equals just a bit over 2½ years (40 credits per year).

Note that the courses surveyed do not perfectly reflect a student's path through the program. The program is being developed continually, and what we see here are rather like snapshots of what the respective years were like in 2001. When the first year students come to the second year in 2002 it will not look exactly as the second year did for the students who took it in 2001.

The teachers responsible for the courses were interviewed by Khalid El Gaidi of KTH Learning Lab. The interviews were around 60- 90 minutes for each teacher. A couple of teachers answer for more than one course. The interviews were conducted during the period March - October 2001. See interview checklist in Appendix (in Swedish).

The questions that were not considered in the specific course or by the specific teacher were omitted. At the end of each interview, each teacher had the opportunity to give any other information they thought relevant about the course.

The notes from the interviews were compiled by Kristina Edström of KTH Learning Lab.

Result of the survey – the 20 compulsory courses

Objectives and aims

When asked about the course objectives and aims, most teachers referred to the written course documentation. Only 3 teachers spontaneously related the objectives. It is interesting to note that one of them mentioned only the objectives directly related to the subject matter. In the written documentation this course had several objectives for generic capabilities, but the teacher mentioned none of these. It would have been useful to ask all teachers to give a spontaneous version of course objectives, and then compare them with the written ones. Unfortunately, this was not planned in advance; they were not asked to formulate the objectives from heart.

On studying the (written) objectives of the 20 courses we find that they are all expressed in very general terms. The distinction between aims and objectives is vague. In no case does it seem possible, neither for students nor teachers, to determine whether students have attained the objectives or not.

Only in two courses the objectives were clearly expressed in terms of learning outcomes, what the student can do as a result of learning. In a few more cases it would be easy to reformulate the objectives into outcomes. But in a large majority of courses the objectives were teaching-centred and/or content-centred ("the course gives an introduction to x, y and z", or "students should understand x, y and z".)

In most of the written course objectives, aspects of general capabilities are mentioned, such as problem solving skills and communication skills. The objectives also reflect ambitions for higher level thinking. This is expressed in terms such as independent thinking, scientific or engineering approach. In some course objectives there are comments about how the course is connected with other courses or with areas of professional activity.

Conclusion

Today the course objectives are not written in a form that can be used as a basis for designing learning activities, assessment, or evaluation.

Pedagogical model

No teacher referred to pedagogical theories for their pedagogical model.
Examples of answers were:

- Practical examples
- Lectures and recitations
- Traditional teaching
- Lecture hall based teaching
- Laboratory work gives examples of theory
- Students formulate "real problems" and construct models
- Conventional
- Teaching is most important, thereafter literature

Conclusion

The pedagogical model in practically all the courses surveyed is what is referred to as "the traditional model". At KTH this means lectures, recitals (where a teacher solves problems) and laboratories.

Diagnostic

In 1 out of 20 courses, the teachers tried to find out, by discussion in class, what previous knowledge the students have. No course did any systematic testing for diagnostic purposes. Several teachers referred to knowing what is being taught in previous courses.

Conclusion

Few teachers check on students' working knowledge in a structured way. This may reflect the view that what has been taught in previous courses has been learned and can be immediately used.

Lectures, recitals and labs

Out of 20 courses in the survey
20 courses have lectures, in average 36 hours each
19 courses have recitations, in average 25 hours each
12 courses have labs, in average 14 hours each
1 course has 8 hours of field trip
1 course has 8 hours of study visits

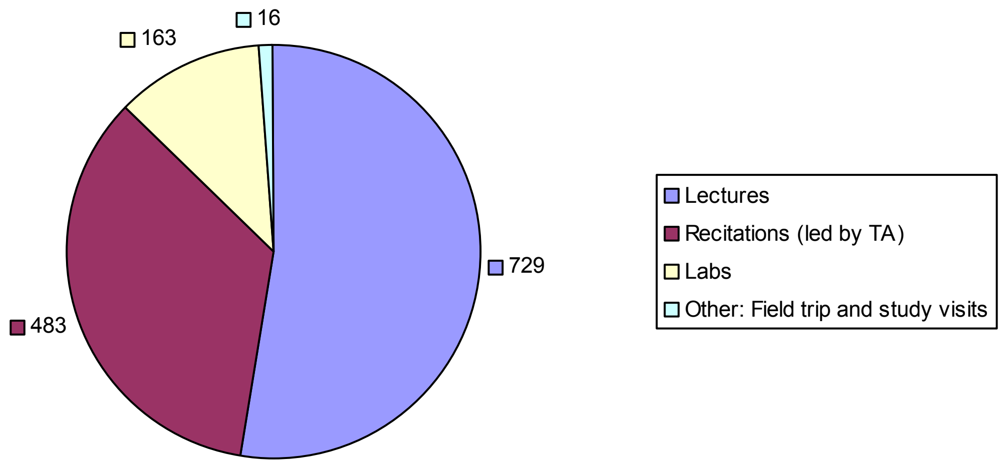

Figure 1. Total number of hours of different teaching activities offered.

In the first 103 credits of the program, which equals a bit over 2½ years, students are offered 729 hours of lectures, 483 hours of recitals led by TA:s, 163 hours of labs, and 16 hours of other activities (a field trip day and study visits).

However the picture presented here is probably too coarse, as we think some of the time may contain seminar-like activities, student-led presentations etc. Activities are probably just classified as recitations or lectures, mostly depending on what kind of room they are scheduled in. It would have been interesting to ask about the nature of the activities; i.e. how many hours are student-led.

Conclusion

There is no doubt that the traditional teaching activities – lectures, recitals and labs – totally dominate the surveyed courses.

Relation between activities

In lectures, the teacher provides the theories, and in recitations the TA demonstrates problem solving based on the theory. Recitations are also teacher-led, with more examples of solving problems. Laboratory work is considered as a practical application of theory. In a majority of courses theory is planned to come before problem-solving or labs.

The difference between lectures and recitations is often unclear, as lecturers also solve problems and recitations often contain theory.

Conclusion

Practically all the courses surveyed have a deductive (bottom-up) approach, starting with theory, then problem-solving and then practical application.

Student – teacher interaction during lectures

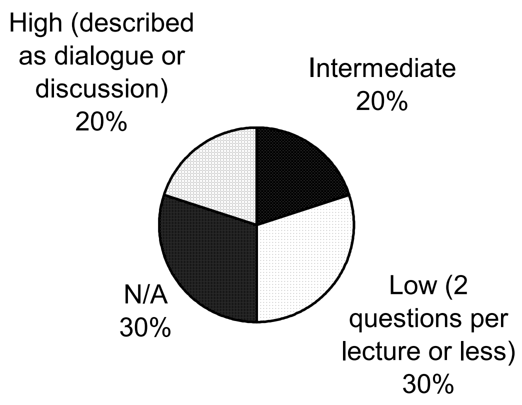

Figure 2. Level of student – teacher interaction during lectures.

Level of student – teacher interaction during lectures is illustrated in Fig. 2. We classified student – teacher interaction as high in 4 courses. High levels of interaction means that lectures were described as dialogue or discussion. In one course students were asked to come up with suggestions how to solve the problems, in another they had to present how they had solved problems.

In 7 courses the teachers described low levels of interaction in lectures. We drew the line at 2 questions per lecture or less. Students were considered passive during lectures, and the questions were often only asked during breaks.

In 6 courses the teachers did not mention interaction during class.

Examples of answers:

- I try to have a dialogue during lectures, but it doesn't work.
- I get lots of questions during breaks. Students are too shy to ask during lectures.
- Students are passive during lectures and recitals.
- I run the lecture as a dialogue.

Conclusion

While most teachers consider students' interaction with teachers important for learning, only a minority of teachers seemed to have strategies for achieving interaction in lectures.

Opportunities for student – teacher interaction outside class

In most courses there are several options to contact the teacher outside class. Most teachers have consulting hours, offer e-mail help, or even have explicit open door policies.

A few teachers have rules, which are clearly intended to influence students to try solving the problems themselves. They must ask a friend first, or students must come to the teacher's office in a group.

Examples
- I always keep my door open.
- I book two hours before the exam when students are welcome to come for help.
- Both the teaching assistants and I answer e-mail.
- Our department always has a teacher on duty that can help with all our courses.

Conclusion

In most courses students have several possibilities to contact teachers outside class.

Student – student interaction

14 of the 20 courses contained labs or group assignments, where students were organised in groups. In one of these courses students were acting as opponents to each other's work.

In 6 courses there was no consideration of collaborative work in the design of the course. However most of these teachers encouraged students to work together, and informal study groups are common. They are spontaneously formed by the students themselves, and not considered in course design.

Conclusion

A majority of the courses contain group work. Other collaboration is encouraged but not organised.

Assessment

Of 20 courses

20 courses have a written exam
12 courses have one or more assignments
7 courses have compulsory labs
4 courses have project work
1 course had compulsory lectures

All 20 courses had a written exam. In 3 of the courses, the final exam was the only assessment activity.

12 of the courses have assignments. In some courses the assignments give credits (often 1 credit out of 4 or 6) or bonus points for the exam. Assignments were never graded as far as we understood. Unfortunately, we did not specifically investigate how much and what form of feedback students get during the course, on assignments and otherwise.

In several courses one or more mid-term tests are given throughout the course (Sv: kontrollskrivningar). They will typically give bonus points for the exams. In one course the students could choose to take two small tests during the course instead of the theory part of the final exam.

Examples of answers:

- Students can choose to take the theory part of the exam as two small exams earlier in the course. This encourages them to study continuously in the course.
- Small tests during the course give bonus points for the exam.
- Project work is assessed both with a written report and an oral presentation.

At least 3 courses had open book exams. In one course students were allowed to bring any aid, except other human beings. We saw some examples of innovative exam tasks.

Examples

- One of the tasks in the exam is to formulate a question and answer it. This gives up to 20% of the result.
- The exam task is to apply their knowledge to a new area, the questions are related to an article or a product sheet.

We specifically asked if teachers used any taxonomy to classify assessment tasks. 2 of 20 teachers referred to some categories of Bloom's taxonomy. About half of the teachers mentioned some criteria for judgement. The criteria were only communicated to the students in very few courses.

Examples:

- Students cannot reach the level of synthesis. They use the methods without thinking, so when they put them together the result is disastrous.
- The two last problems in the exam are for students who want grade 5.

Conclusion

It is impossible to find a course, which doesn't have a written exam. Some innovative assessment ideas are implemented within the bounds of the traditional exam.

Assessment criteria are seldom used as an instrument to guide learning, as they are neither explicit nor shared with the students. Assessed learning outcomes are not related to any taxonomy.

Evaluation

All 20 courses have course evaluation questionnaires. Some courses also had formative evaluation, either as meetings with student representatives or as discussions in class.

For 15 of the courses we received a compilation of questionnaire results. Some of these teachers had published this report on the web to share results with the students.

From a few courses we received impressive full documentation, including minutes from the course analysis meetings. Minutes record discussions between student representatives and teachers, changes from the previous years were followed up etc. Since KTH policy states that all courses have to follow this procedure it is possible that the other courses also have this kind of documentation, however we did not receive it.

Teachers were asked why they evaluate. They all expressed a sincere wish to improve the course and their teaching in general. A couple of teachers also mentioned the teaching assistants' need for feedback. No teacher even mentioned the KTH evaluation policy as a reason to evaluate.

Sometimes teachers find that information from the evaluation can be confusing. Many teachers express that they try to change the things that are criticised, but they have observed that other alternatives may not be more popular.

Example:

- The course book was criticised in the evaluation, so we changed to another book. But next year, the new book was criticised too, so we changed back.
- It is difficult to find the right pace. Some students will always be unhappy.
- It is difficult to find the least common denominator of students' complaints.

Conclusion

All courses are evaluated with a questionnaire.

Teachers express a general wish to improve the courses and their teaching. But it seems unclear to some teachers how evaluation can be used in a systematic way in course development.

Appendix B2. Report from Chalmers.

BENCHMARK OF TEACHING PRACTISES

@ Mechanical Engineering, Chalmers

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Introduction

In order to be able to improve teaching (and thus learning) it is essential to know the status of teaching (in a broad sense). In the CDIO project this is looked into from different views, *e.g.* “what we teach” as given by the syllabus (Curriculum theme), or “how we teach” which is the topic of this work reported here (in the Teaching and Learning theme).

To investigate teaching at Mechanical Engineering, a survey of the compulsory courses in year 1-3 were carried out. A major part of the work consisted of interviews with teachers. They were asked about how a course is planned (lectures, exercises etc.), what type of examination that is used, interaction between students and teacher, use of new technologies etc. In parallel to the interviews other sources of information were used like course PMs and course home pages.

Method

The number of courses surveyed was in total 24, all of them compulsory courses during year 1-3.

The teachers responsible for the courses were interviewed for about 60 minutes each. The interviews were conducted during February and March, 2001. The interviews were based on a question checklist, see Appendix A (in Swedish) with questions concerning:

- Aims and objectives of the course
- Pedagogical model
- Test of knowledge status in the beginning of the course
- Planning of the course (lectures, recitations, lab, …)
- Use of technology
- Interaction between student and student/teacher/other
- Motivation of course
- Course info
- Assessment
- Evaluation

Result of the survey

General result

Each interview was of course different from another but some general observations were made. It is clear that a majority of the courses are of the form:

- Lectures are given where the teacher goes through a chapter/part of the text book,
- Recitations are carried out to illustrate the lecture/lectures,
- There are larger exercises which should stress certain important aspects, exercises which should be presented in writing (usually using a template) and sometimes orally,
- Sometimes there are laboratory exercises where theory should be given a practical meaning. Laboratory exercises are, however, expensive and not very common.

Another impression from the interviews is that most teachers have a view of how “their” course should be organized (content, how many lectures, exercises etc., examination and so on) to be a “good” course, but also that not many have contemplated alternatives to a traditional course (meaning lecture based).

Aims and objectives

To most of the teachers (almost all) there were no difference in the meaning of the words “aim” (syfte) and “objective” (mål). Consequently these two words were used as synonyms in *e.g.* the description of the course and its aim/objective.

The aims/objectives that were formulated for the course are not of the kind maesurable learning objectives, but more of the overall kind, quite diffuse (many people would refer to these as “aims”). The only place where objectives could be seen is in old exams, a well known fact to most students.

Pedagogical model

All teachers said their model was a traditional one with lectures, recitations, labs etc., but nobody would say that they chose this model as a result of pedagogical reasoning. My impression is not that this model was chosen because it was an easy way out, more that this was something that worked. Also, alternatives to the traditional model are not known to most teachers.

There are some exceptions from this, but not many. The belief in the traditional lecture is strong, and if this is to be changed there is a large task to "retrain" teachers. However, to do this it should start withshowing that it could be shown that there are better alternatives (better than traditional lectures) and also it is necessary to allocate time and resources for improvements.

Diagnostic (test of knowledge status at the beginning of the course)

In no course was there a test at the beginning of the course testing the students knowledge in relevant topics (from previous courses).

Planning of the course (lectures, recitations, lab, …)

A "typical" course consist from 46 % lecture, 35 % recitations, 9 % assignments, 5 % laboratory work and 5 % projects. One would think that this would change much from course to course but the scatter is not very large. Examples of exception are the courses in mathematics where recitations are common (see the Algebra example below), and Environmental technology where there are no recitations.

Use of technology

The technology that is used is mainly computer and computer programs, but it is not very common. In a few cases the internet was used as a means to find information.

Interaction between student and student/teacher/other

The general response from the teachers were that there was the "normal" interaction, with the teacher in the lecture room, with other students when studying the subject and sometimes other whenever there was a guest lecturer appearing in the course.

This is of course a difficult question when asked to a teacher since she or he should answer what they think about the student situation. However, the question still gave some information whether or not interaction is a part of a course.

Motivation of course

It is common with an introduction to the course and its content. The size of this introduction varies, however, depending on subject and on teacher.

Course info

Information about the course is usually given two ways, a short version on paper which is handed out at the start of the course, and on the course home page (usually much more detailed than the "start up paper" handed out at the first lecture). New information which appear during the course are also commonly distributed via the home page.

Assessment

In all courses there is a final written exam. The *standard* procedure for these exams is four hours to answer a set of problems (a combination of theory and calculus) and to pass 40 % correct answers is needed. This then gives a grade of 3, to get higher grades (4 or 5) 60 or 80 %is needed.

However, it is common with additional parts to pass the course, like large exercises (small projects) with written and/or oral presentations. Grading is not common. In some courses it is possible to pass the course (grade 3) only through some of these exercises but to get higher grades you have to get a good result on the exam.

Also, laboratory work, whenever a part of the course, usually is compulsory (but without grading).

Evaluation

All courses have a compulsory evaluation at the end (after the exam usually). In these evaluations students participate plus teachers and course administrators.

The main purpose of the evaluations is to be a feedback to the teacher (from the students) what worked and what did not. Since we only interviewed taechers in this survey only the teachers view is presented, students may see it differntly.

Alternative course planning

Strength of materials, M2

Strength of materials is compulsory to all 150 second year students at Mechanical Engineering as well as to the 30 students of Industrial Engineering Design. These students have all studied basic mathematics and mechanics needed for the course. It is given as one of three parallel courses and ranges over an entire semester (16 weeks). The course is an introduction to the subject strength of materials and the basic problem solving methods applied. Thus the aim of the course is to give a broad and basic education of the parts of the subject which are relevant to a mechanical engineer rather than to give a deep understanding in a more narrow area. After examination the student should have knowledge about common problems within the subject strength of materials, be able to design simple constructions, have enough knowledge to judge when a more thourough analysis is needed, and to be prepared for further studies within the area.

Education is given as lectures where theory is covered (2 + 2 hours/week), recitations where problems are solved by a teaching assisatant (2 + 2 hours/week), and design tasks with problems to be solved independently but with support by assistants. During the course 6 design tasks are handed out. They should be presented in writing and is graded either as pass or fail. Three passed task presentations are needed to be admitted to the final written exam. There is also a small test during the course. This is voluntary and gives bonus points for the exam. To pass the course the student can either pass the written examination, or pass the small exam and pass 4 design task presentations.

It is stated that the student should be prepared to work 200-250 hours plus the scheduled lectures and exercises (approximately 90 hours) to assimilate the course material.

Algebra, M1

The algebra course is built around the common context of linear algebra, such as concepts like vectors, matrixes, determinants, complex numbers, polynomials and algebraic equations. The course is organized in "theme weeks" as follows:

Days 1. An introductory lecture for 2 hours with an introduction to the theme, the area of the following week, objectives and goals, examples, important theorems and relations.

Days 2 & 3. The students work in small groups of 4 with a total "class" of about 30 students and with one teaching assistant. The teaching assistant serves as a coach but can also demonstrate further examples within the content area for the whole class. More extensive questions are left to be worked on after class.

Days 4. The students are examined on that week's work.

Days 5. A concluding lecture for all students.

Important to the organization is the students working in groups of 4, thereby encouraging discussion and, according to the examiner, encouraging learning by explaining to someone else. Another important idea is the week 2 assignment, larger problems on which the students are examined on day 4, orally and in written form. The students are also encouraged to write a journal over each theme week in order to reflect on their learning. The journal also contributes to the evaluation in the examination. The 14 homework problems and 6 journal writings can altogether give a maximum of 20 points, and every student needs to have at least 12 points from this part of the examination to pass. In addition, the students need to gain at least 12 points from the 30 points awarded in the final examination. In the fall of 2001, 180 students were admitted to the program of Mechanical Engineering at Chalmers, which started with an introductionto the algebra course on September 4 and ended with a final written examination on October 25.

Compulsory courses at Chalmers Mechanical Engineering - organization

Course	Code		Period				Points	Lect.	Recit.	Assignm.	Lab	Proj
			1	2	3	4		hours	hours	hours	hours	hours
Ingenjörsmetodik	MMF171	M1	x	x			4	24		12	6	12
Matematik/Envariabel A	TMA081	M1	x				4	28	42			
Matematik/Envariabel B	TMA081	M1		x			4	28	42			
Matematik/Algebra	TMA021	M1	x				4	28	42			
Matematik/Flervariabel A	TMA082	M1			x		4	28	42			
Matematik/Flervariabel B	TMA082	M1				x	3	28	42			
Matematik/MATLAB	TMA066	M1	x	x	x	x	2	8	0		8	
Mekanik A	MME031	M1		x	x		5	28	28	12		
Mekanik B	MME031	M1				x	3	26	16			
Miljöteknik	MEN125	M1		x			3	40				20
Termodynamik	MTF041	M1			x		3	26	26		4	
Materialfysik	MMK180	M1				x	3	28	20	4	4	
Hållfasthetslära	MHA062	M2	x	x			6	48	52	24		
Numerisk analys	TMA095	M2	x				3	28	28	16		
Energiteknik	MEN011	M2	x				3	28	14	14		
Metalliska material	MMK025	M2		x			5	30	26		16	
Systemteknik	MPR260	M2		x			3	14	14	14		
Maskinelement kö/rit	MMF021	M2			x		3	6		12		
Maskinelement						x	5	30	22	24	4	16
Tillverkningsteknik	MPR092	M2			x	x	5	42	12		14	30
Polymera material	MPM079	M2			x		3	24	10		4	
Grundl. strömningsmek.	MTF051	M2				x	3	26	24		12	
Matamatisk statistik	TMS060	M3	x				4	28	28			
Industriell ekonomi	IEK101	M3	x				4	34	12			
Elektroteknik	MPR115	M3	x	x			5	42	36		14	
Arbetsorganisation	IAR035	M3		x			4	28		18		
Styr- & reglerteknik	ERE031	M3		x			4	28	24	8	4	
Projektledning	IEK345	M3			x		3	25		4		

Appendix B3. Report from LiTH.

Project: P6: "Benchmarking Teaching practices"

Madelaine Engström
LiTH

A benchmarking of current teaching practices at the program Applied Physics and Electrical Engineering (Y) at Linköping Institute of Technology. Interviews have been done with teachers at the compulsory courses and on the two profiles of specializations: Biomedical Engineering and Electronics. This report will describe the result of the 28 interviews with teachers in compulsory courses.

Introduction

The overall objectives for the CDIO-project are to develop new models for engineering education. In the project, the four universities Chalmers, KTH, LiTH and MIT collaborate. One of the projects in the CDIO is Teaching and Learning. In this project a benchmarking of current teaching practices at LiTH have been done. The results of the survey will be used to develop and improve the program Applied Physics and Electrical Engineering.

Method

The survey has been done through interviews during the period March-April 2002 with teachers in compulsory courses and teachers in two of the profiles of specialization's, a total of 39 interviews. In this report the interviews with the teachers responsible for the compulsory courses in the first three years of the program will be described. It is 28 interviews with teachers responsible for the compulsory courses.

Since the interviews were done some changes have been made to the program. Two project-courses based on CDIO-skills have been developed, and are now compulsory courses in the program. These courses are not in this survey.

A survey form has been used in the interviews. The questions were about the course and its organization, objectives, aims, pedagogical method, interaction, assessment and evaluation.

The interviews were among 1-2 hours each. Most of the teachers have been positive to the interview. Some of them quoted that this was an opportunity for them to reflect over different aspects of their own course. In some parts it was the first time they ever had to think of their course in a special way.

Results

Objectives and aims

In every course the teacher has given an objective with the course. The objective often describes that the students are going to control methods, get to understand, be able to identify and formulate problems, se structures, give basic knowledge, to learn construct etc.

About half of the teachers have objectives with the course, which describe what the students will be able to do after the course. The others have given objectives that are more general and only describe what the students are going to know or have knowledge about, after the end of the course.

Aims are more difficult for the teachers to describe. Four of the teachers did refer to the objectives when they were asked to explain the aims with the course. 6 of the teachers couldn't say any aims with their own course.

Pedagogical model

Most of the teachers said that they use a pedagogical model in their course. Often the model is the traditional one with lectures, recitations and laboratory work. Many of the teachers said that they wanted the students to be active. Examples of methods to get them active was: do experiments on the lectures, don't show overheads until the last 15 minutes of the lectures so the
students will listen to what the teacher say, instead of just writing down what's on the overheads. To get the students to be active one teacher said he gave keynotes to the students instead of answer questions.

The teachers, who said that they didn't use a pedagogical method, also worked the traditional way with lectures, recitations and laboratory work.

Relations between lectures, recitations and laboratory work

The 28 compulsory courses of the program offer a total of 656-hour lectures, 239 hours of recitations and 286-hours of laboratory work. There are 118 hours of seminars and 12 hours with a mentor.

The average compulsory course at the Y-program has 23 hours of lecture, 24-hours of recitation and 10-hours of laboratory work.

The relation between activities is often that the teacher in the lectures presents the theory in the course. In the recitations the students solve problems more independently related to the theory in the lecture. Laboratory work is a practical application of the theory.

In one course the relation between the activities was a little different. In this course the students start with laboratory work, then recitations and finally the lectures. The teachers said that he wanted the students to be curious, that's why he start with laboratory work and have the recitations in the end of the course.

Interaction

Teacher-Students

Lectures with more than 100 students are a very common teaching-model in this survey of teaching practices. In large groups it is very difficult for the students to get a close interaction with the teacher. Students are usually very passive during lectures. Many of the teachers in the interviews said that there are seldom questions asked by the students at the lectures. If the students ask questions it is during breaks. In lessons, where the student group usually is not so large as in the lecture, the teachers said that the students don't ask much there either. Even in a smaller classroom with thirty students the group can be too big to bring a warm and safe atmosphere so everyone feels free to ask questions.

Some of the teachers have tried to change pedagogic model just to get closer to the students.

Examples of changing models to improve the interaction between teachers and students as some teachers described them at the interviews:

-Have options to contact the teachers outside class by consulting hours, e-mail help open door policies.

-Problembased learning, a method were the students work in small groups. This pedagogical method leads to many questions and discussions with the teacher.

-Lessons which are organized in sessions. The students are divided in small groups of 10-12 students. The teacher has the ambition to get to know the students better by using small groups to discuss problems. The teacher tries to create a safe atmosphere to encourage strong interaction between the students and the teacher.

Students-Students

Most of the teachers said in the interviews that the students seemed to form their own study-groups. Some form of collaborative work was included in several courses. That meant often that the students were working two and two on a lab, which hardly can be teamwork. Only in a few courses where there was collaborative work, the students could not choose their group members by themselves.

A majority of the courses did not include collaborative work, reference working in a group with 4-6 members, where there is a common objective which is known by everybody in the group.

Motivation

In 24 of the 28 compulsory courses the teacher had a strategy to get the students motivated for the course. Examples of answers:

- Try to show how to use the theory in a practical way.
- Give examples from industry.

- Be as enthusiastic as possible
- Show funny examples.

Assessment

Of 28 courses:
11 courses had written exam
10 courses had written exam and laboratory work
2 courses had laboratory work as the only exam
2 course had assignments
1 course had exam they do at home
1 course had project work
1 course had compulsory lectures

21 courses had written exam.

In two courses one mid-term test is set. They will give bonus point at the final exam.
One course had laboratory work and assignments as exam.
One course had a written exam the students did at home and a project work.

Only one teacher said he uses a taxonomy. Some teachers said they were thinking in that way but couldn't say the use a special taxonomy.

Evaluation

Some form of evaluation is done at every course. Since LiTH started with a questionnaire on the web, many teachers were frustrated because they didn't get any feedback from the results of the evaluation and when they received the result only a few students had answered the questions.
The teachers appreciated most of all the meetings they had with the student's representatives. They thought that was a good opportunity to discuss the course and to listen to the student's opinions.

The purpose of the course evaluation is for most of the teachers to change and improve the course. Some of the teachers said that they evaluated the course to know if the students liked the course, if they thought they had learned something and if the thought it was a funny course.