

EXPERIENCES OF LEARNING

student accounts linked with theory

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1 Introduction

The CDIO Initiative is an international collaboration to reform undergraduate engineering education. To start with, at least one program is being reformed at each participating university: the Royal Institute of Technology (KTH) in Stockholm, Linköping University in Linköping (LiU), Chalmers University of Technology in Göteborg, and the Massachusetts Institute of Technology (MIT) in the United States.

The CDIO Syllabus¹ is a set of goals for engineering education, which explicitly includes personal, interpersonal and professional skills. It is the basis for curricular improvement and outcome-based assessment. The initiative takes on a strong program perspective, as the aim is to influence our students' total experience of their programs. This means involving all courses and teachers in the program. Faculty, students and administrators from the four partners work together and meet regularly to exchange experiences, methods and ideas.

CDIO Initiative participants work in five teams: Curriculum, Teaching and Learning, Assessment and Evaluation, Workshops and Laboratories, and Student team. The Student team initiated and carried out a survey of learning experiences in order to better represent a majority of students. The student team discovered that it lacked a framework to interpret the data, and was therefore uncertain how the findings could be used to improve the education. The solution, the students decided, was to team with the Teaching and Learning team to link survey data to literature, and to a previous teacher survey in the same programs².

During the survey, the Student team discovered that many students attributed the quality of a course mainly to a "good teacher" or "bad teacher". The students have an important role in improving education but if they just focus on the individual teacher they will never discover and suggest possible changes in teaching methods, assessment and planning that might improve their courses. Therefore, one objective with this report is to spread knowledge among students about how course design affects their learning.

Another aim is to show that pedagogical theories are appropriate to describe our programs, and our students' experiences. The intention is to provide evidence and data to refute arguments that pedagogical theory is not applicable to our students, our subjects, our special circumstances, or even that these theories have nothing to do with reality. This report will support the Students team work by sending out the message about necessary change to our programs.

Our aim was not to create new knowledge in the field of teaching and learning. Instead we aimed at using existing knowledge as a framework to improve our understanding of students' experiences in the programs.

2 Method

2.1 About the interviews

When the students decided to carry out the survey, the work with developing the questions started. We wanted to achieve good answers that also would make the interviewed students reflect on their learning. The questions of the survey are found in section 2.2.

There was a discussion about whether to have group or one-on-one interviews. When students are individually interviewed, they answer questions without being influenced by others. The benefit of group interviews is, however, that the discussion that would appear, will bring the reflection one step further. Finally, the interviews at Chalmers and KTH were done in groups. The group interviews were audio recorded and later transcribed. In Linköping the interviews were done one-on-one and recorded by taking notes. It turned out that the answers were very consistent among the three universities, independent of the interview format.

The participating students were chosen randomly from year one and year four. In total 56 students were interviewed by members of the Student Team.

2.2 Questions

These questions (number one to nine) were aimed at answering the three main questions of the survey:

How do you study now?
How do you want to learn?
What do you expect from the teacher?

1. Describe your program: How do the courses generally work? What methods of teaching have you experienced?
2. Which methods do you use to learn outside scheduled hours and how do they work?
3. What motivates you in your studies? What influences/decides - how much you study? – when you study? – the kind of study task you do?
4. What do you feel is the focus of learning in your classes now? Does this focus help you? Do you feel that you can apply your knowledge afterwards? What kind of focus would improve your learning?
5. What is it that defines the course to you? How do you know what to study and when you have succeeded? What if these sources say different things? What are most important?
6. How does the assessment influence your way of studying?
7. Do you feel efficient while you study or do you think you could do more/better? If so, What could change your way of studying?

8. Have you had any classes that have especially inspired and motivated you? How did the class accomplish this? Did it enhance your learning in that subject area?
9. What changes or other learning methods would you like to see implemented in classes to improve your learning?

3 Analysis and selection of topics

We did not analyse the questions separately. Instead, we started to notice themes that were permeating the students' answers. **Assessment** was the dominating theme. In fact, it did not matter much what the original question was, the answers almost always concerned some aspect of assessment. The second most common theme was **Motivation**. We also identified the themes **What defines the curriculum**, **Interaction**, **Approaches to and quality of learning** and **Time/planning**.

We chose to look at the answers from these different views in order to give recommendations in different areas. These themes are all interdependent, and all themes contain some aspect of assessment and motivation.

For each theme we looked for theory to give us a framework for interpreting the students' statements. We have used literature which was fairly accessible also to engineering students who do not have a background in pedagogy.

Our primary sources are:

- John Biggs, *Teaching for Quality Learning at University* (1999)³
- Graham Gibbs, *Improving the Quality of Student Learning* (1992)⁴
- Graham Gibbs, *Using Assessment Strategically to Change the Way Students Learn* (from *Assessment Matters*, ed. Brown & Glasner 1999)⁵.

The theory section for each theme consists mainly of reviews and quotes from these sources. We apologise for any misinterpretations.

These authors draw upon important sources which would have been interesting to read first-hand, had the scope of this project permitted a more thorough literature survey. Among the most important are Marton and Säljö (deep and surface approaches to learning), Snyder (the hidden curriculum), Miller and Parlett (cue seekers), and Feather (the expectancy-value theory for motivation).

4 Themes

4.1 What defines the curriculum?

4.1.1 Theory

How do students know what defines the course? Do they read the course objectives and other official information about the course, note what is said in lectures, read the literature, do the coursework or study old exams? Which sources are most important?

Students quickly learn to see behind the formal curriculum (as expressed in the course objectives) and orient themselves to **the hidden curriculum**, which is defined by what counts in assessment. It can be very different from the official curriculum, which often aims at a higher level of understanding.

Cue-seeking or cue-conscious students will work out hints about examination, they will find out what is the hidden curriculum. The **cue-deaf** students are unaware of this aspect of assessment. The extent to which students were cued in to the assessment system is a strong predictor of their overall performance.

In summary: It is not curriculum which shapes assessment, it is assessment that shapes the curriculum. Or even: **Unless assessment tasks mirror the curriculum, they will erode it.**

4.1.2 Results from interviews

The **course objectives are not used** as guidance by the students. This was expected, as most courses in these programs have objectives written in formats like: “students should gain an understanding of...”³. The course objectives are considered “fuzzy” and it is not possible for the students to see when they have reached the objectives. Instead, the students focus on other sources that are more important to them:

Student quotes:

- The course objectives are very unclear and they don't give that much [guidance]. It's pretty hard to know what 'good knowledge' is. By testing yourself on previous exams you get a clear picture of what you know.
- The course objectives are so huge, the lecturers bring up what is most important.
- I have no idea what the objectives were in the compulsory courses I've taken. It's more like 'this is a course I have to pass'.
- The course syllabus applies to the beginning of the course, and towards the end you work for the exam.

The **course literature** is mentioned by a few students who have a special interest in the subject, but many do not read the text books.

Student quotes:

- I often don't read the books.
- If I'm interested in some subject I try to know it really well, for example by reading the course literature.

Many students follow the **coursework schedule** (recommended problems to solve each week).

Student quotes:

- I do what we have been recommended to do. I believe that covers what I have to know. I feel efficient when I get the tasks done.
- When I study I do what's in the coursework schedule. Sometimes I read a page in the book.

It is overwhelmingly clear that **what really counts to the students is the assessment**. Assessment shapes what students are oriented towards in their learning. All students **study exams from the previous years** in order to understand what is important in the course. The exam has the **overriding importance** over anything else, be it the course objectives or the recommended coursework.

Student quotes:

- You focus on the exam. If you know what the exam will be about, you will study that.
- In [course] the exercises in the book were not like the exam tasks, and then you do old exams instead. Focus is only on the exam, unless the coursework tasks are similar.
- To get a higher grade you need to be able to solve the problems that are different each year, but to pass you only need to practice on five previous exams.
- If I have a written exam I often try to be really good at certain parts of the course. I look in old exams for typical exam tasks [in those areas] and learn those.

Many students report that they are cue-seekers, trying to **find out what will be assessed**, in order to concentrate on that. Lectures are the primary source of cues.

Student quotes:

- If you don't go to the lectures, you'll miss what is considered important. Then you have to study all of it.
- The goal is set by what will be on the exam, which in turn is based on what the lecturer says during lectures.
- The course is defined by what the teacher says will be on the exam.
- The teacher goes through problems that are similar to those that will be on the exam, so that more [students] will pass, irrespective of knowledge.

Cue seeking is also done **collaboratively**.

Student quotes:

- It is difficult to set your targets, you are eager to compare these with what others think, so you don't do the wrong kind of work.
- Before the exams it feels good to work together so you know that you don't do the wrong things.

Towards the end of their education, some students are entirely familiar with the assessment system:

- After some time at [university], you get a feeling for what and how much you need to study. (student in year four)

In summary, students strategically orient themselves towards **the hidden curriculum**, which is defined by assessment. This would not be a problem if assessment was properly aligned to the objectives, but in reality the hidden curriculum can be **very different from the official curriculum**.

Student quotes:

- I'm sorry. The exams aren't always so difficult and you can actually make it through [university] without knowing very much.

4.1.3 Recommendations

In order to clarify the requirements in a course, students have to understand the course objectives. They must know when they have fulfilled the course objectives. Expressions like "After the course you will have a good understanding of XYZ" should be replaced with "After the course you will be able to...". It is important that the course objectives are realistic, so they can be applied in real-life situations.

The cue-seeking game should not be necessary. Don't "drop hints". Define the course clearly in the course syllabus. Refer to the syllabus regularly so the students learn how to use it themselves.

Students will generally focus on what is assessed. Therefore, the assessment should be designed to guide students to do exactly the appropriate kind of work. This means that assessment must be in harmony with the course objectives. A hidden curriculum should not exist.

4.2 Assessment

4.2.1 Theory

Assessment dominates in several ways what students are oriented towards in their learning.

Assessment affects student learning by

- Communicating, or rather: defining, the intended learning outcomes.
- Generating time on task.
- Distributing the time spent working during the length of the course.

- Generating the kinds of learning activity the students will do.
- Providing feedback on progress.
- Affecting which learning strategy students will adopt (deep or surface).

The strong influence that assessment has on student learning can be used as a positive force. **Constructive alignment** is when teaching and assessment are in harmony with the objectives. Assessment will affect student learning in a beautiful way when the assessment tasks generate appropriate learning activities, help students getting started and keep working across the course, give early success which drives motivation, and provide timely feedback that the students pay attention to.

On the other hand, badly designed assessment will be a strong negative force. **Unless assessment tasks mirror the official curriculum they will erode it.** The hidden curriculum is shaped by the assessment requirements, and can be very different from the official curriculum. **Backwash** is when the assessment system will allow (even reward) a lower level of understanding than the intended learning outcome.

4.2.2 Results from interviews

Assessment is often mentioned in the interviews. Note that aspects of assessment are mentioned in all other themes.

A previous study² has shown that all courses in these programs have final exams (with a few exceptions at Linköping). Students reported that final exams caused them to **postpone their studies** until the last moment, even though they know that it is a bad habit. Throughout all interviews, the message came through clearly:

Student quotes:

- In a course with a final exam you feel that learning the content can wait, and then you don't spend so much time.
- In courses with just a final exam, then you only sit [studying] the last two weeks.
- Some courses you neglect until the week of the exam. You can actually cram in some courses in a few days.
- I think final exams are hard, because then I think that it's not until six weeks later that I need to know this, and I can relax until then.
- In a course which has assignments you do them, but otherwise I mainly cram for the exam.
- I can think that this time I will start early and do a little each day. But it has never happened so far. (student in the fourth year)

The intense cramming for exams may tax students' energy to such an extent that they are **too tired to start working on the new courses**. It can lead to a vicious circle, where the student gets a bad start in new courses due to fatigue from the previous courses.

Student quotes:

- After an exam period you only want to rest, because you are very tired after having studied so much. Instead, a new study period begins with new courses and you are far from motivated to begin studying.

Assessment tasks early in the course will help the students **getting started** with their studies. Giving the necessary igniting spark is an important function of assessment.

Student quotes:

- Deadlines are good, you get more motivated to get started with your studies with a little pressure.
- Tasks that you have to do during the course makes you start studying and you get into the subject earlier.

Many students report that continuous assessment helps them **spend more time** on the course. The pressure from deadlines makes the students keep up.

Student quotes:

- Several smaller tasks during the course is good, because I probably do more work in those subjects.
- Assignments are really good because they force you to study during the whole study period.
- If you have deadlines all the time, then you spend time on the subject.
- A little assignment each week makes people work better and gives the students time to learn during the course.

Students also report that they **learn better** from doing coursework during the course than from intense cramming for exams. This may be because they spend more time on task, but it can also be because coursework leads to more effective study habits.

Student quotes:

- When assessment is spread over the whole duration of the course you learn better.
- The things I remember from a course is the parts we had assignments on. Then I really sat down with the problem and worked out the solution myself. If you work on old exams, you check up the correct answer right away, and then move on without really learning.

In summary, continuous assessment tasks helped students get started, made them spend more time on the course and also learn better. However, students fear that the **total workload could be overwhelming** if parallel courses all have continuous assessment.

Student quotes:

- It doesn't work to have quizzes in three parallel courses because you have to prioritise between the subjects.
- If you would have three courses in parallel which don't have final exams you would be totally burnt out.

A big issue is that it is possible to **collaborate on assignments without learning** much from the process. All students who mentioned this problem felt that it is wrong but they saw no

other way. Two reasons are mentioned: the assignments are considered too difficult, and many students have not yet started working actively in the course.

Student quotes:

- When the assignments are too difficult what happens is that one person does all the work, because the others haven't got started studying in the course. It's not meant to be like that, but that's what happens anyway.
- Assignments are good because they help you getting started in a course. Unfortunately they are often done in groups with the result that one or two people solve them for the whole class. There should be more individual milestones.

One student had experienced a simple and clever arrangement which can be applied to **avoid the above mentioned problem** with assignments. All students were to be prepared to present the assignment in front of their peers. This created social motivation:

- In one course we had calculations as homework twice a week. Every time the teacher picked a student at random who had to present the week's task. This gave motivation [to prepare], because you did not want to stand up and say that you couldn't do it.

How the assessment is designed will also **affect the kind of work** the student will do. One example which is mentioned is **aids in exams**. Examples of aids are textbooks, books with formulae, or the student's own notes. An exam where **aids are not allowed can encourage students to adopt a surface approach**, because they focus on memorisation instead of understanding. Being allowed to bring aids will change how and what students do to study before the exams, as memorisation is no longer necessary or relevant. Another important consequence is of course that the teacher cannot construct the same kinds of questions for open book exams.

Student quotes:

- In the first years you are mostly not allowed to bring any aids to the exams. Then you don't focus on being able to apply this knowledge afterwards, but more on what you are supposed to learn in the course.
- I once wrote an exam where you were allowed to bring 'everything'. There you had to first understand the problem, and then how to solve it. I think that feels more useful.

4.2.3 Recommendations

Start assessment early to help students getting started. Have assessment tasks continuously in the course to help students spend more time on the course and learn better. Try to find a level of difficulty which helps students learn. If the assignments are too difficult, many students will not be able to learn from them. Make sure assessment gives prompt feedback to students.

Establish the habit to pick students randomly and ask them to present homework in front of class. This creates a strong motivation to be prepared. The effect comes from the students knowing in advance that this will happen, it is ineffective if used as a surprise. Try to create a friendly atmosphere around this activity, it should not feel threatening.

Assessment must be in harmony with objectives, otherwise assessment will create a hidden curriculum which overruns the official objectives. Make clear what is expected of students.

Think carefully about the aids you allow in tests. Allowing aids will change the way students prepare. A good learning activity for the students may be to produce their own aids, for instance two sheets of notes.

4.3 Motivation

4.3.1 Theory

Students' motivation can be described by the expectancy-value theory of motivation. Two factors make students want to learn:

1. They must perceive the topic to be important; it must have some **value** to them
2. They must expect that it is possible to accomplish the task; they must **expect success**.

Motivation is the result of these factors multiplied. If either of them is zero, then motivation is zero.

Let us take a closer look at the perceived value of a task, the first factor in the expectancy-value theory. What kinds of value can the learner assign to the task? We see four categories:

- **Intrinsic motivation:**
performing the task because of their own interest. This can have a **consumptive** dimension, when the task itself brings immediate satisfaction, or **investive**, when doing the task will contribute to future satisfaction. Deep learning is strongly related to intrinsic motivation. When students are intrinsically motivated, they experience a need to know, they have ownership over their own learning, it matters to them.
- **Social motivation:**
performing the task in order to please people whose opinions are important to them. Social motivation is a good precursor to intrinsic motivation. Teachers can create social motivation by being role-models and displaying enthusiasm for their subject. The social dimension of many learning situations will increase motivation, as it is important to students to look good in front of peers and teachers.
- **Extrinsic motivation:**
performing the task because of the value they attach to what the outcome brings. The outcome itself is more important than learning. The task is something that has to be got out of the way in order to pass the course, receive the student loan etc.
- **Achievement motivation:**
performing the task in order to compete and win. Here, learning is less important than winning, and the task must be handled as grade-effectively as possible.

What about the second factor then? What will influence a learner to expect success or failure?

Previous experience is the most direct way to influence expectations. After success, the student will expect to succeed again, if the conditions that are believed to lead to success are the same. One important difference is whether the student attributes their success and failure

to factors over which the student has control, such as effort, or to factors that are uncontrollable, such as luck and dependence on a particular teacher. Attributing failure to factors that can be changed by the student, helps the student overcome previous failure.

Clear goals and criteria are important to make it possible for students to expect success. Students must know where they are going, and know what work they have to do in order to get there. Expectancy is at risk if the course communicates unclear or unreasonable goals, for instance when trying to cover too much content. Criterion-referenced assessment sends a message to the students that it is their effort that counts.

Giving students **feedback on progress** early in the course is important. Formative assessment will help students get started and keep working, and offer a chance of “early success” which, in turn, enhances motivation.

4.3.2 Results from interviews

Let us compare what the students’ responses to the theory from literature. The expectancy-value theory says that motivation is the product of **the expected success** and **the perceived value** of the task.

Naturally, prior success is a beneficial factor. Also, providing opportunities for **early success** in a course will spur motivation.

- If you get the right answer on a calculation assignment you continue with the next one and it gets fun. If it’s difficult you get unmotivated and you spend less time on it. One should really put more time into things that work badly but it doesn’t work that way.
- When it works well it’s easier to study and then the whole course feels more meaningful.
- I want simpler assignments in the beginning so there isn’t a high wall to climb. It’s better to start low and then raise the level of difficulty.
- If you can make it the first year, it feels like you will make it through the whole program.

Clear goals and criteria can help motivation.

- To increase motivation, the design of the course could be improved, better structure and a main thread is needed.

It is probably less likely that students will expect success if they are influenced by an incident such as the following:

- I had [a course] where the course evaluation from the previous year was read aloud, and where 80 % of the students stated that the course was too difficult. The lecturer commented the figure by saying that you students have insufficient prior knowledge, and then he ran the course in the same way [as the previous year].

The other factor, the perceived **value** to the learner, can be classified into four dimensions: intrinsic, extrinsic, social, and achievement motivation. The two most important kinds of motivation, **intrinsic motivation** and **social motivation**, are mentioned by all students very frequently:-

Intrinsic motivation is connected to deep learning and satisfaction. Some students may bring intrinsic motivation with them when entering the course, but it is important to note that it can also be created during the course.

- The interest for the subject is the most important. It can be an prior interest or it can be created during the course.
- With some courses I can feel ‘Oh no not another math course’. But then you get some understanding for something in that course and then it feels great fun in a way.
- I spend much more time on courses that feel relevant to me, but at the same time less, because it’s easier for me to pass these exams.”

Reaching a deeper level of **understanding** is clearly desirable. What is mentioned above all is **being able to apply** the knowledge. This clearly gives a sense of ownership. On the other hand, rote learning (learning through memorisation without understanding) is perceived as boring.

- Knowledge is motivating. Being able to answer a question makes you feel motivated and you think it’s fun.
- [These] courses are interesting because we solve problems. Then you learn better and it’s more fun. They are also better connected to what I want to work with and that’s why they become more interesting.
- Courses with experiments are motivating. You get a deeper understanding and see that it’s not just a formula, but something you can also apply.
- To really understand a subject is much more fun.
- If the first year courses were more applied they would be more enjoyable. More coursework and less theory so you learn to solve basic problems.
- Some courses are very theoretical and based on rote learning. They tend to be very boring.
- In the fourth year courses focus more on problem solving, which is very satisfying to be able to do on your own.

The influence of **the teacher** is considered extremely important.

- In [one course] the teachers were carefully chosen and really wanted to share what they were doing. Then it was so fun that you almost want to go on over the break and just hear more. In other courses the teacher seems almost forced to stand there.
- Some lecturers made you interested in their subject, some failed completely, so you thought that you never want to take that subject.
- It depends totally on how the lecturer is, the subject itself can be so and so.

- You need an entertaining teacher who helps you keep up interest during the class.
- I want encouragement in form of praise and personal contact with the teacher.

In many cases, the social motivation also comes from **peers**.

- Having study mates helps you getting up in the morning to go to school.
- In one course we had calculations as homework twice a week. Every time the teacher picked a student at random who had to present the week's homework. This gave motivation, because you did not want to stand up and say that you couldn't do it.

Extrinsic motivation is also present.

- Totally honestly, you often study just to pass the exams. Sometimes the subjects are interesting but not enough to give the energy it takes to learn all of it. When a course is compulsory it's not as much fun even if you thought so in the beginning. Then you just study for the exam.
- When you start on a job you will do completely other things anyway and the education is just to prove that you are able to learn and understand things.
- You study just to get the credits so the money keeps coming.
- I take the education to be able to work with the things I want and get a better salary than without an education.
- In certain courses you feel that you don't want to learn more than what it takes to pass. I feel that there is nothing in [course] which I will have use for and that I find interesting.

We have only interpreted one remark as **achievement motivation**, but perhaps even this one should be classified as **social motivation**:

- Now when my friends have started to graduate I've automatically become more efficient.

4.3.3 Recommendations

Provide students with an opportunity for early success in the course. In that way they feel that they are capable of managing the course, which is very good for motivation. One suggestion that a number of students mention in the survey is to start with easier tasks and then increase the difficulty.

Understanding is satisfactory in itself. If students have a good command of the fundamental parts in the course they will feel a lot more motivated to go on and learn more. A good tip is to have a quiz early on, covering the basic knowledge of the course. This will encourage the students to start study early in the course and to learn the fundamental elements of the course before moving on to more complicated concepts.

The instructor plays a very important role in university education. The survey offers many examples of how students are motivated by a teacher who exhibits enthusiasm for the subject. Teachers who show that they care about their students gets respect and creates motivation.

Most students need to see applications and real world examples in order to understand theory. Students do not like to do things that appear unnecessary or of little practical value to them. Merely memorising theory without understanding is perceived as useless, because it will be forgotten soon after the exam. Avoid having a view of your subject as an end in itself, try instead to explain why the knowledge is important to an engineer.

4.4 Interaction

4.4.1 Theory

Group learning is **inherently motivating**, as it brings about social motivation. But discussion is also an **active process** where students have to formulate and externalise their current understanding of topics. Exposure to contributions from teachers and peers will make **variation more visible** – including different interpretations, different levels of understanding, different perspectives, and controversy. Therefore, it is easier to negotiate meaning and to manipulate ideas with others than alone. These factors will potentially enable a **deeper approach** to learning.

Informal student groups can be very effective. **Students teaching each other** is an excellent learning activity, whether it is in formal or informal contexts. The student who does the teaching will learn more from the process than the student who is taught. This will not come as a surprise to most teachers, who have experienced first-hand that teaching is a process from which the teacher acquires a deeper understanding of the subject.

4.4.2 Results from interviews

On the question how they study during non-scheduled hours most students answered that they **study in informal groups**. They cite two main reasons. The first is the **social motivation** that was created by studying with friends, and the second that they **learn better from teaching each other** in the group. To some, studying alone was the preferred mode for reading.

- It's easier to get out of bed in the morning when you know you're going to meet friends. Of course you spend some of the time just chatting but in total it's more efficient as you help each other.
- I always study in a group because I learn much better then.
- I study in a group where we help each other and solve problems together through discussions, that you can't do alone.
- I study with another student. It works well. Explaining to others helps me understand better.
- I do some studying alone, it's most effective for reading theory but it takes more self discipline.

When discussing how teaching can be improved many of the students indicated a desire for more **interaction with teachers**. Smaller groups were often mentioned as offering better contact with the teacher and thus better understanding.

- It's easier to ask questions to the teacher when you are in a smaller group because you get a more personal contact with the teacher. Often the teacher is under less stress during a recitation. During lectures you can only ask questions during the break and then there are lots of students that want to ask questions.

Interaction with teachers **outside scheduled hours** was mentioned a few times.

- During my specialisation I've had a very good teaching assistant who you always can go to but he will not just give you the right answer straight away but makes you understand. (fourth year)
- I've never tried to reach a teacher at his office. They probably don't have time for us. (first year)

4.4.3 Recommendations

Plan activities that create peer interaction, such as opposition, discussions, role play, group assignments etc. This is active learning.

Think about how you answer questions. Try not to just give a right answer straight away, but guide the student to understanding the issue herself or with peers.

Be clear about how and when the students can contact the teaching team. Discuss in the teaching team how you can show a respectful attitude to students.

4.5 Time/planning

4.5.1 Theory

Lack of time, either because of too high academic workload or because of non-academic priorities, is a strong factor that induces a surface approach.

A particular source of anxiety and cynicism is time stress brought out by an obsession with coverage. There are too many topics, each taught with equal emphasis. **Covering too much content is the greatest enemy of understanding**. Deep engagement in a task takes time. If you do not provide the time, you will not get deep engagement.

There are many reasons why students are subjected to time stress:

- lack of coordination between teachers setting assignment deadlines
- insisting on the prime importance of what you teach yourself
- lack of knowledge or even concern about the students' perspective on the workload
- shared teaching, and particularly shared assessment, where each teacher thinks his or her own contribution being the most important
- generally, a lack of care and forethought in designing the curriculum initially

4.5.2 Results from interviews

In the following paragraphs you will find the interviewed students thoughts about time and planning.

The time plan of the courses is of great importance for the students. There are many examples of students criticising the course objectives for being **excessive** which causes a feeling of deficiency.

- I don't like that you never have time to understand and to go deeper in material.
- I think many courses dig too deeply into a subject for just being four credits. You only have time to touch the surface of a huge subject area.
- In many cases there is no chance to have time to learn everything in a course, even when you really wish to.
- You have no time to work just to keep up with the course, instead you put all effort into the required parts.

Teachers in parallel courses need to **coordinate** the time schedule of their courses to keep the workload equal during study periods. This is particularly vital when it comes to assignments and other forms of continuous assessment.

- Even with good planning, project courses often take too much time which affects negatively on the other courses.
- It doesn't work to have quizzes in several parallel courses because you always have to prioritise between the subjects.
- If you would have three courses in parallel which instead of a final exams have assignments, seminars and quizzes, you would be totally burnt out.

Students report that **projects and group work** take more time than individual work. There are **additional demands** from group dynamics, project administration etc. But the interaction is very **rewarding**.

- Group work is less effective, but you reach further than if you study by yourself.
- Projects take much more time. Just like in working life, you have to make the collaboration work and have common goals, even when you end up with that besser-wisser there and that jerk there.

4.5.3 Recommendations

A good way to avoid stress is to determine how much time the students are spending on coursework. Collect regular feedback from the students (on hand-ins and in evaluations) on the actual time spent on tasks. Share the information with the students. This declaration is also a good way to help students to plan their time and to understand how much time they have to spend on a course.

Find an educational model that keeps the students active! Too many scheduled hours with only "sit and listen" lectures will make the students passive and is experienced to be time

wasting. Instead, spend lecture time on the main parts of the course and on parts that students find difficult. Through weekly assignments, difficulties in the course can be discovered and students will find the lectures more relevant if they get answers to their questions. When students are better prepared, they will find lectures more interesting and learn better.

Another important way to avoid stress is to coordinate quizzes and assignments with the other teachers. One suggestion is to arrange planning meetings for the teachers of parallel courses.

Try to make the amount of content in the course realistic and prioritise the most important parts. Avoid trying to cover “everything” in a course. Clarify what parts of the course that are fundamental and work with this early in the course.

4.6 Approaches to learning / Quality of learning

4.6.1 Theory

Students have different intentions and motivations driving their learning tasks, they are trying to achieve different things, and this affects how they go about their learning. Two extreme approaches to learning have been identified: surface approach and deep approach.

In the **surface approach** the intention is to reproduce the subject matter at a later date, typically in an exam. The focus is on isolated facts; items treated independently of each other. This prevents students from grasping the meaning and structure of the subject; they cannot see the woods for the trees. (Emotionally, learning becomes a drag, a task to get out of the way. Hence, the presence of negative feelings about learning: anxiety, cynicism, boredom.) Memorisation is not in itself a synonym to surface approach, as it is a meaningful component in some contexts, such as when learning vocabulary in a foreign language. Instead, memorisation becomes a surface approach when it is used instead of understanding, in order to give an impression of understanding.

In the **deep approach** the intention is to make sense of what is learned. The focus is on underlying meaning: on main ideas, themes, principles or successful application. This requires a sound foundation of relevant prior knowledge, so students will naturally try to learn the details, as well as making sure they understand. (When using a deep approach in handling a task, students have positive feelings: interest, a sense of importance, challenge, pleasure.)

A surface approach is disastrous for the quality of learning outcomes. Knowledge is both poorly structured, and rapidly forgotten. It is clearly possible to achieve a good grade using the surface approach, as long as the assessment system allows the student to get a good grade on the basis of memorising facts. But exam results do not predict long term retention at all. The reason for this can be that intensive revision for exams involves a surface approach. In contrast, knowledge gained through understanding results in long-term retention. Coursework results are a good predictor of long term recall.

An approach is not the same thing as a skill, or a characteristic of the student. Instead, **most students can adopt both surface and deep approaches** to their learning. Students will respond strategically to the perceived demands of the courses. Inappropriate course design, teaching methods and assessment can foster a surface approach. Some students, however, may only be able to adopt a surface approach, because their present conception of learning does

not make it possible to go about learning in any other way. (Students who take a surface approach have a different view of what good teaching consists of from that of students who take a deep approach.)

4.6.2 Results from interviews

Many students clearly describe studying using a **surface approach**. They tell about **ineffective study habits** when concentrating their studies to the end of the course or when they study old exams. Memorisation is used as a substitute for understanding. This is bad for motivation and long-term retention.

- Most courses are based on learning by heart. In the first years you are mostly not allowed to bring any aids to the exams. Then you don't focus on being able to apply this knowledge afterwards, but more on what you are supposed to learn in the course.
- Take away rote learning, you lose it quickly anyway. More understanding!
- When you have a written exam you often sit in the last moment cramming.
- The things I remember from a course are the parts we had assignments on. Then I really sat down with the problem and worked out the solution myself. If you work on old exams you check up the correct answer too quickly and then move on without really learning.
- Passing the exam is no guarantee that you remember anything of what you learned.

It seems that for a majority of students **the route to understanding is through application**, not through derivations and theory. The focus of many courses is seen as mainly theoretical, and many students point out that **theory is memorised for the exam** rather than applied and understood. Interviews with teachers have also shown that practically all courses have a bottom-up approach, starting with theory, and only after that problem-solving and practical application². It seems that this approach is badly received by the students:.

- In some courses you are supposed to know every little step of the derivations. It feels unnecessary, it would be better to know how to arrive at something than learning it by memorisation.
- We should move the focus more to application, to get a grip on what it's all about. I don't feel that I can apply the knowledge I have.
- Connection to real problems is good. You don't want to sit there with a theory cake which you cannot eat from.
- What the teachers want to know is if you've studied the theory. You often study for the exam and then forget. Instead of focussing on why and how you do something, it is much rote learning.
- I want to see the practical use before theory, because that motivates the theory.

Another reason to take a surface approach is **time pressure** due to **content overload**.

- It's a pity that there's no time to enter deeply into one's studies, there's no time to digest.
- I think they want us to learn a lot of unnecessary things 'just in case'.
- Many courses dig too deeply into a subject for only four credits. They include too much and you only have time brush against the surface of a huge subject.
- To really understand something I need to spend a long time on it by myself.
- It feels like I forget very much nowadays, that probably depends on my study habits. I know that I should practise repetition but I never have the energy to do that.
- Of course you should really know all of it to be a good engineer, but it just isn't possible.

Some students have experienced courses that were successfully designed to **promote understanding**.

- The new [course] really got an understanding approach and you're allowed to bring books on the exam. Knowing by heart is really useless. It is much more fun if you understand, and you remember much more.

Some of the students, especially in year four, have clearly found intrinsic motivation. It seems that their **deep approach to learning is effective**.

- This is really my dream education because I want to design vehicles. I spend much more time on the courses which feel relevant to me, but at the same time less time because I pass the exams easier.
- In year four you understand more about what you're doing, you absorb knowledge much better when you know how it can be used.

4.6.3 Recommendations

Try to discourage a surface approach and encourage a deep approach.

Do not attempt to cover everything in the course. Obsession with coverage causes time stress and encourages a surface approach.

Being able to apply the knowledge is very motivating to the students. Use applications and real examples to motivate and explain theory. To most students a satisfactory level of understanding is "being able to use". The objective should be that students are able to use theory, not just repeat it from memory. Then assessment must be designed accordingly. Otherwise many students will try to memorise theory for the exam, after which it will be quickly forgotten. This is a waste of time for both students and teachers.

Therefore, focus on working knowledge of basic concepts and provide connections to reality. This will encourage a deep approach, which means more effective study habits and better long-time retention.

5 Conclusions: Top ten requests with rationale

- 1. Set clear objectives that are relevant to the engineer: “After this course you will be able to...”**
This will increase motivation.
- 2. Design assessment tasks and teaching that are relevant to the objectives.**
This will define the course objectives to the students and engage them in the appropriate learning activities. Motivation is strong when students experience a need to know things in order to carry out tasks that matter to them.
- 3. Focus on working knowledge of basic concepts and provide connections to reality. Application is the road to understanding theory.**
This will encourage a deep approach to learning by increasing intrinsic motivation, giving better understanding and long-term retention.
- 4. Prioritise. Remember: coverage is the enemy of understanding.**
This will reduce time stress, which is an important reason why students adopt a surface approach to learning.
- 5. Set an assessment task early in the course.**
This will help students getting started and provide an opportunity for early success, which is a motivation factor. Getting feedback in a timely, effective manner, will help students learn.
- 6. Set assessment tasks regularly during the course.**
This will help students spend time on tasks and keep up the pace of work. Getting feedback and responding in a timely, effective manner, will help students learn.
- 7. Make sure students know exactly what is expected of them. Produce explicit criteria for assessment.**
This will take away the hidden curriculum and reduce the cue-seeking game.
- 8. Design tasks and activities with built-in interaction. Use both peer interaction and student-teacher interaction.**
This will increase social motivation and encourage deeper understanding.
- 9. Make a realistic plan for the time the students spend on the course. Get regular feedback on the actual time spent on tasks. Coordinate deadlines and workload with parallel courses.**
This will reduce time stress.
- 10. Show with your enthusiasm that the course and its tasks are worth doing.**
This will promote social motivation.

6 Acknowledgements

The CDIO initiative is financially supported by the Knut and Alice Wallenberg foundation.

We would like to thank

- all interviewed students for your time and your straight answers.
- all students in the CDIO project, especially:
 - o Anders Claesson, the Chalmers student who held and transcribed their interviews. He would have been a co-writer if he had not travelled to China.
 - o Sofia Hedenstierna, student at KTH who was active writing the questions and doing interviews.
- Bill Litant, MIT, for help with the English language
- Sören Östlund, KTH for full support and useful comments

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