EXCURSIONS AND PARTICIPATION FROM COMPANIES IN A WEEKLY 5 ECTS COURSE

Lisbeth M. Ottosen & Iben V. Christensen

Department of Civil Engineering, Brovej, Building 118, Technical University of Denmark, 2800 Kgs. Lyngby

ABSTRACT

A major factor when choosing the teaching methods in a new weekly 5 ECTS course was to enhance the student's engagement and responsibility for own learning by setting a frame enabling them to visualize themselves as civil engineers. The course is "Materials Durability and Repair" and it is offered to civil engineering students (both at bachelor and master level) as an advanced and elective course. A maximum number of students in the course is set to 25 for practical reasons. Excursions to relevant sites with structures suffering from decay or where repair actions take place was one important teaching method. The excursions took place preferably as introduction to a new part-topic so the students had a common knowledge platform from where the more theoretical teaching could set off. The teachers experienced higher motivation from the students when the excursions were before the lectures on the connected topic than vice versa, probably because the ability to relate the theory to the real life made the topic seem more relevant to them. At the excursions the students took samples which they analysed in the laboratory at the university to enhance the active learning. As these samples are from real sites, they also reflect the huge variability at such sites and sometimes the results did not support the theory. The frustration of not knowing all upfront places the student in a situation well known to working engineers and formed background for relevant discussions. Experts from companies took part in planning of some of the excursions and gave lectures on "real life cases" during the course. This involvement from companies introduced the students to the engineering community which they will join in the future. The companies engagement was important both to the training of scientific engineering skills and professional skills. Also important to the training of professional skills was the deliverables from the students, which was dissemination of own work in articles and a poster presentation performed in groups of 5 students. Student evaluations of the course were positive and currently the course is running for the third time. It is oversubscribed and has a waiting list, underlining the need for such a course.

KEYWORDS

Excursion, active learning, company participation, professional skills, problem based learning

INTRODUCTION

The overall learning vision when recently designing a new DTU course was to enable the students to identify themselves as civil engineers simultaneously to learning the required technical engineering skills. The aim is to foster a class of self-directed and reflective students who take responsibility for own learning as they can see a direct link from the taught topics to their future career.

The course connects the taught topics to the everyday life of many civil engineers and thus the course is supporting the CDIO education. Excursions and company involvement are powerful tools towards fulfilling the overall learning vision. The course aims at teaching the professional engineering skills (e.g. working in teams, communication in writing and orally) simultaneously to the technical skills. This is attained as suggested in [1] by implementing the professional skills as a matter of teaching and learning, rather than as an addition of new subjects in the existing curriculum (in this case technical curriculum).

The present paper reflects on the teaching methods used, including involvement from companies in relation to the overall learning vision.

About the course

The name of the course is “Materials durability and repair” (course 11569 at DTU). It is a 5 ECTS course and currently running for the third time. The course is offered to civil engineering students, both at bachelor and master level as a BSc/MSc- Advanced Course i.e. it is an elective course. It is compulsory for the students to have passed a basic course in materials science for civil engineers before enrolling. Foreign students have participated every time and the course is taught in English.

Material properties, decay and repair methods for three major groups of porous building materials - concrete, stones/bricks and wood - form the scientific and technical basis of the course. Each material is treated separately with the same emphasis. There are though also transverse topics and activities relevant to all three groups of materials linking the course topics together and increasing the general knowledge on durability of porous building materials. Depth of learning rather than the breadth of coverage is achieved by focusing on selected porous materials.

The general course objective given in the DTU course catalogue is “The participants will be able to determine damage mechanisms on construction materials in various situations and act upon the findings by suggesting an appropriate method for repair”.
The learning objectives of the course are developed in accordance to Bloom´s taxonomy [2] (which is the standard at DTU):
A student who has met the objectives of the course will be able to:

- Perform inspection on existing structures in relation to damage of materials
- Select and perform relevant laboratory analysis to support damage assessment
- Identify situations with risk for materials decay
- Debate damage mechanisms and transport routes
- Describe special repair issues when dealing with cultural heritage
- Select materials which are durable under given exposure
- Suggest and discuss methods for repair and maintenance

The first time the course was offered as a 3 weeks course during the summer 2009. There were 16 students. The course was then offered in the spring semesters 2010 and 2011 and taught once a week (4 hours) during the whole semester (13 weeks). Both times with the maximum numbers of students allowed (25), and both times about 40 students applied, but

the excess of 25 were declined participation. The maximum number of students is 25 due to the practical limitations of the laboratory equipment used.

TEACHING METHODS

Using the classification of the student´s interest in the course from [3], there are probably few students in this elective course to whom the motivation lies within "(1) Only waiting to pass the subject". The first day of the course the students briefly present themselves orally to the class and this introduction includes the interest in the course (why enrolled?). It is probably not many students, who during this introduction would admit that they are only waiting to pass, but few students have told that one important reason was that the appointed time for the course fitted into a gap in their weekly timetable. These students may fall in group (1). The majority of the students are from the two groups "(2) A desire to accumulate useful knowledge for their future career, which students still see as a distant future, though one which exists for them" and "(3) An interest in looking more deeply into the specific knowledge of construction and building materials". The student are thus expected to be relatively well motivated when the course starts, and the teaching should continually seek to feed the motivation of both groups, i.e. at the same time stimulate the student´s vision of themselves as civil engineers of the group (2) students and the scientific curiosity of group (3) students.

Making the students visualize themselves as civil engineers and act as such is a good background for the development of professional skills to become a natural part of the course. According to [1] teaching professional skills in engineering involves considerations about learning and development of competences among students. This includes how the choice of teaching methods create the context in which the engineering students learn and how the teaching design interrelates and facilitates the learning of professional skills. Throughout this course varied teaching methods are used to support learning of both technical skills and professional skills. The combination of teaching methods is made to support active learning in this semester course. In relation to each of the three groups of construction materials there are an excursion, lectures, and laboratory work. Each of these methods is discussed in the following in the context of the course.

Excursions

As the students generally lack personal experience in assessing damage in relation to building materials the learning process for each material was preferably set out with an excursion. These excursions went to an old concrete bridge, to a wooden roller coaster and a walk through the centre of Copenhagen, where the topic was salt damage of brick and natural stone. The students took samples for the experimental work at these excursions. Further a visit to The Danish Technological Institute (a self-owned and non-profit institution) was a part of the course in relation to wood decay and protection. All together these four excursions are a central part of the course.

As the build environment continuously changes and the repair of structures has a limited duration, the locations for the excursions changes from time to time. However, one excursion for each of the three main construction materials is planned. In the phase of planning the excursion, the network of the course teachers is utilized and different engineering companies as well as colleagues at the university are consulted in order to get an overview of relevant localities. At the excursions the students meets experts from outside the university, who introduce the students to the problems and solutions at the actual site. The experts are from different disciplines as engineers, architects, researchers and craftsmen.

The purposes of the excursions are multiple. They create a sense of community in the group and in relation to the learning of scientific and engineering principles the excursions are used

directly to form a common knowledge platform. They also enabled the students to relate to the topics taught theoretically in class to actual cases and thus give reflective students. The excursions are important in relation to having the students visualizing themselves as as engineers working in a team with people of different professions.

Before the excursions, the students only had a very brief introduction to the topic. Few times it was impossible to have the excursion before the in-depth lecture from practical issues, so the order was changed. From the experiences with this, the students clearly seemed more motivated and active in discussions during the lectures in the cases where the excursions were first. However, in the course evaluation made by the students at the end of the course two students have suggested always to have the excursions finishing a topic and no students commented on the reverse order. From the teachers point of view it is easier to teach the topic in class when the excursions were first because the excursions had formed the common knowledge platform among the students in which the teaching could take a starting point.

After the excursions the students elaborated in groups on the most important new knowledge to remember in their future life as civil engineers and a common discussion in class on the topic followed.

Lectures and exercises

Traditional classroom lectures is another teaching methods in the course – though problem based learning is used. As stated above these in-depth lectures were preferably given after an excursion had opened the topic. After the excursions, the students visualize many of the topics taught. During the lectures the theoretical topics were related to the real life examples; either to findings from the excursion or through pictures of e.g. structures suffering from the actual type of decay or relevant repair actions. When available, material samples were used in the lectures. This line of giving the students a “feel” for the topic is in accordance to the suggested by [4]: “Probably the most effective strategy is to relate the new concept to an existing real-world problem.”

The classroom lectures were alternating with group work either as experimental work in the lab or written exercises, to engage the students and support their active learning.

Most of the classroom lectures were given by the two course teachers, but also other DTU experts and in few cases experts from engineering companies were involved in this teaching activity. This was to offer the students committed people with a high technical knowledge for every topic taught. The course teachers participated in the lectures given by others to be able to discuss with the students and relate to the lectures later in the course.

One lecture was dedicated to introduce the research topics of the two course teachers. The aim of this lecture was to illustrate to the students that new knowledge is continuously developed and that there are problems with building decay, to which there is actually no solution available. Some of the students may in their future career work together with researchers or visualize being a researcher themselves and this lecture gave them an insight into this professional life.

Laboratory work

Laboratory work was integrated in the course to support the students understanding of the theories learned during the lectures.

Samples for later analysis in the laboratory at DTU were taken at the excursions. These analyses were conducted in between the relevant lectures (same day). The students learn

both simple quantitative methods (which often can be used in the field), and complex qualitative methods. From these real samples the students from time to time went through the frustration of the analysis not supporting the predictions - a situation known from an engineer's life as well. Such frustration and the following re-thinking are rarely obtained using samples well known to the teacher as we tend to choose otherwise, i.e. samples clearly supporting the theory. The active learning from real samples stimulated relevant discussions.

INVOLVEMENT FROM COMPANIES

To support the overall learning vision – enabling the students to visualize themselves as civil engineers – the participation of people from companies plays a key role. The involvement of companies has also the positive effect that some of the expectations to the young people when they enter the civil engineering workforce become clearer to the students as well as the teachers, and this was used indirectly during the overall planning the course.

Engineering companies have been involved when finding sites for some of the excursions and one company also taught how to take core samples from concrete. This involvement ensures high practical relevance of the examples used and it increased the interest of the students. From a consulting company we obtained samples from a previous inspection of a concrete bridge together with anonymised reports. The students performed analysis and compared the results to the results in the report. Possible differences were discussed and the students saw a real-life report on the topic.

About two hours at the final part of the course is dedicated to "Repair Seminar". Speakers from companies (4-5) were invited and they gave presentations on real cases, which relate to the topics taught during the course. By this the students were presented with cases similar to what they can be involved in during their later carrier and they meet the type of people they are going to work with. However, it is important to choose good speakers otherwise the students soon become impatient and loses concentration even if the topic was highly relevant. The overall topics covered during the Repair Seminar have been chosen by the course teachers and do not vary from time to time, but the speakers and thus the presentation of the topic does. This means that there are variations, but these variations reflect real life situations.

The experience from the involvement of companies was that they were very positive towards participating in the course. Everyone we contacted had a positive attitude towards our inquiry, but in a few cases the fact that the presentation had to be given in English made presenters exclude themselves. There were no payment for their effort, but many of the involved experts even thanked for the opportunity to disseminate their experiences to the students.

ASSESSMENT OF THE STUDENTS

The student worked in groups of five persons and the first two times the course was given the groups wrote four articles of four pages after a fixed template (from a scientific journal) and a short report. The first three articles focused on the hands-on-work with each of the three materials. For the final paper, the students made a more thorough investigation on a relevant site (chosen by themselves). In addition to the articles the students made a poster presentation, and this was followed by individual examinations. The workload of the students was too time-consuming compared to what can be expected of a 5 ECTS course and the third time the course was offered, the students made two articles, two individual quizzes and a poster presentation. The quizzes support the individual assessment.

Poster presentations and writing articles are two important communicative tools between engineers and thus the choice of these types of assignments underline the major learning vision of the course. The ability to professionally disseminate relevant engineering topics in a short and precise way to others in the engineering community is highly important. The poster presentation and the page limit of the articles forced the students to work actively on focusing and concentrating the message, which is also a useful competence in their future life. The oral presentation of own work in the class is in accordance to [5] where the use of laboratory work and sessions with student presentations was successfully used in a similar course on materials in civil engineering.
The choice of using article writing and poster presentations as assessment methods is a way to support the development of professional skills without significantly increasing the syllabus of the course, though short lectures on “How to write a scientific article” and “What is a good poster?” are given. The latter is supported by a discussion among the students where they evaluate some posters of the teachers. The course was closed with the students presenting their posters to each other.

If there is any single factor that supports good learning it is formative feedback [6] and thorough feedback was given to each group on the articles regarding both the scientific content and the form. For feedback to be effective students need to be clearly aware of what they are supposed to be learning and as they are unlikely to be perfect the first time, they need information as to where their deficiencies lie [6]. The points for improvements were made clear to the students while discussing the first article(s) and these points were expected improved in the final paper. The final paper and poster presentation account for 50% of the student assessment and thus it is shown that the first paper(s) are meant as a part of the learning process itself. The poster presentation is the last day of the course and this day the students also get feedback on their final article. Further an internal journal volume (for this actual course) with the articles from the class is distributed among the students.

The grades given were generally high and this may be seen as result of active learning giving in dedicated students.

STUDENTS COURSE EVALUATION

The course as evaluated by the students using the DTU standard evaluation forms. At present the third course is on-going and student evaluations are only available from the first two courses. Unfortunately the statistics regarding the number of students who have answered the forms are only 56% and 45%. All together 20 students have filled in the form for the two years. Due to this limited number of students, the evaluation may not be representative to all students, but the answers received are quite uniform.
The form has two parts. One is questions where the students evaluate the course on posed questions and the ratings are from 1 (strongly agree) to 5 (strongly disagree). Figure 1 summarizes the answers from the three most relevant questions in accordance to the topic of this paper.

Of the answering students, 60% strongly agreed that the teaching methods encouraged active participation which was one of the major teaching issues when designing the course. No students evaluated this point less than average and the goal seems fulfilled. Similarly it can be seen that the students found good continuity between the different teaching activities. There is an overall satisfaction among the students about the communication on their stand academically. One student disagreed and in the on-going course this point has been given priority.

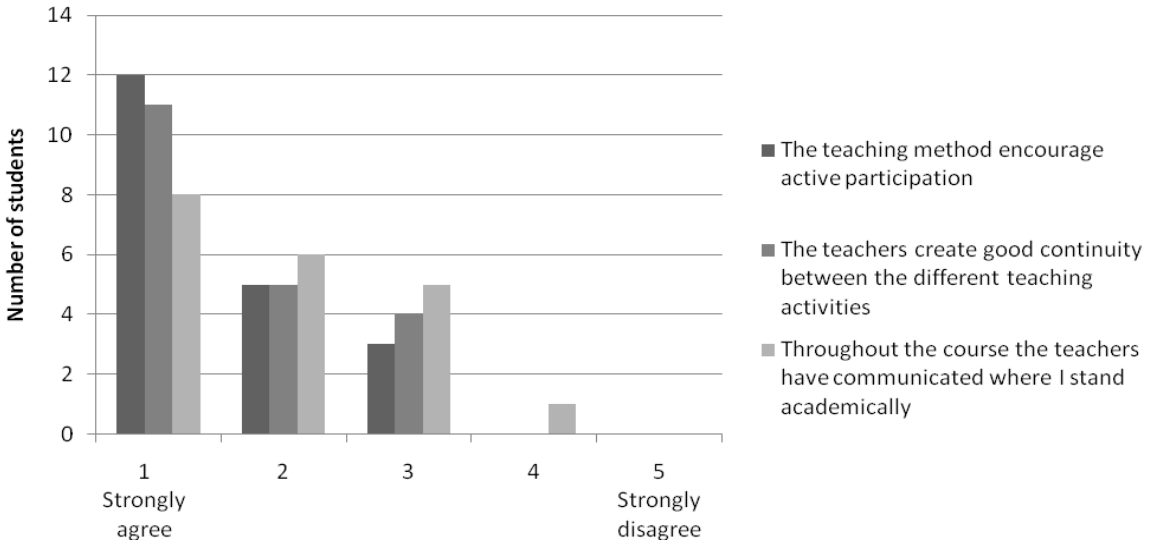

Figure 1: result from the course evaluation made by 20 students (50%).

In the qualitative part of the students evaluation 10 out of the 20 answering students stated that the excursions was a good idea and that they learned a lot from them. Some of the positive comments were:

- In this course, teachers integrate theory with practice, and applied theory to reality. This is a good way for us to learn knowledge.
- Very nice to have lectures/excursions/lab work and experiments. The reports were always fun to write because it was scientific "new" work done on the subject.
- Nice to see the materials in use at the excursions. All topics and articles were interesting.
- It has been nice to have the theoretical knowledge and the practical knowledge parallel. Good idea with trips to the real world.

These comments show that (at least) some of the students appreciated the effort laid on varying the teaching methods and on the variation between practice and theory.

The majority of the comments were positive. One student though complained that it was difficult to keep up with the course if you did not join all the lessons and excursions as some of the topics discussed were not to be found in the course material. This is a point which is difficult to address when having a course planned like this where you e.g. make experiments and discuss the findings, and discuss what you see at site at the excursions even though it was not central in the syllabus from the beginning of the course. Further using the participation of companies is also to loosen the grip on exactly what is taught and the weight of the topics, even though the overall topic always was discussed when arranging with the company. It is not possible to plan every detail on beforehand in the course when linking so much to companies and relevant real life examples as in this course.

PRACTICAL ISSUES IN PLANNING THE COURSE

It was necessary to limit the number of students to 25 (five groups of five persons) mainly due to the laboratory exercises. Highly specialized equipment was used as a Scanning Electron Microscope, where each group spend at least 1 hour with a technician studying their own samples, and other techniques were similarly time and labour consuming. Also the wish

to be able to vary (sometimes ad hoc) between lecture and laboratory work limits the number of students. Sampling at the excursions was also time-consuming at some of the localities (where drilling samples were taken) and a maximum of five groups were able to take samples within the scheduled time.

The continuity of the course is obtained by an initial in-depth formulation of the topics which must be taught. The topics are grouped and persons from industry, who can cover each area are identified. Neither of the activities is formulated so strict that the course is dependent on participation of specific experts. Planning of a course like this involving companies and with hands on experiences through excursion and lab work is time consuming to the teacher, in comparison to a traditional course with lectures followed by well described written exercises. However, this may be time well spend as it is awarding to work with dedicated students.

As the course has been both a three weeks course and a semester course, comparison is possible. It is easiest to plan as a three weeks course as the timing is not so strict to one afternoon a week, but the syllabus has been the same in both cases and there is no distinct difference in the student assessments and evaluations by the students.

CONCLUSION

Throughout the weekly taught 5 ECTS course “11569 Materials Durability and Repair” varied teaching methods are used to support learning of both technical and professional skills. The course supports the CDIO education in its design and teaching methods. Active learning was achieved through a combination of lectures, excursions, experimental work and involvement from companies.

Through excursions a common knowledge platform was formed from where the problem based teaching could set off. Companies were involved in different parts of the course to link the theory continuously to real-life situations. Some of the excursions were planned in cooperation with companies and some solely organized by companies. Further engineers from companies gave lectures on specific topics to consolidate the theory taught by the university lectures. The students were generally dedicated and good synergy between the students and the lectures (from university and companies) was obtained with benefit to all.

The student´s assessment of the course showed that they valued the use of varied teaching methods. Especially they appreciated the excursions and the alternation between theory and practice. The assessment also showed that the students agreed that the teaching methods encouraged their active participation in the course, which was one of the major goals when planning the course.

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Biographical Information

Lisbeth M. Ottosen is associate professor at Department of Civil engineering, Technical University of Denmark. The overall research interest is applied electrokinetics in civil and environmental engineering. The teaching activities are mainly within construction materials (semester courses and student projects at all levels).

Iben V. Christensen is assistant professor at Department of Civil engineering, Technical University of Denmark. The overall research interest is the use of electrochemistry for in-situ impregnation of wood and conservation of archaeological waterlogged wood. The teaching activities are mainly within construction materials (semester courses and student projects at all levels).

Corresponding author
Lisbeth M. Ottosen
Department of Civil Engineering
Brovej, Building 118
Technical University of Denmark
2800 Kgs. Lyngby
Denmark
lo@byg.dtu.dk