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EVALUATION OF LEARNING OUTCOMES IN CDIO PROGRAMME WITHIN CIVIL ENGINEERING

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ABSTRACT

The CDIO approach to engineering education was implemented at all bachelor of engineering programmes at Technical University of Denmark (DTU) starting from the fall semester 2008. The study programme within civil engineering starts twice a year in September and February, and at summer 2010 a total of approximately 200 students have completed their 1st semester on the CDIO version of the programme. The current version of the programme is briefly described in the paper with focus on the Design-build projects and the CDIO – project based courses.

We asked students from the first class in 2008 to fill in a questionnaire about learning environment and their learning outcome related to the CDIO project in 1st semester. The questionnaire was a supplement to another one, which is used for all courses at the university as a standard evaluation form, [1], [2]. The students were asked to fill in the questionnaire during the final part of the semester (December 2008).The results from those evaluations were used to improve the first semester project course, which as a consequence is modified slightly every time, [1].

During the spring semester 2010 the students from the first class are studying their 4th semester and work on a new design-build project. They were asked to fill in a new questionnaire and some of the students were interviewed too. Students' learning outcomes and their experiences with engineering methods were evaluated in the new questionnaire and the interviews. Focus was on students' reflections on how and what they learned, and also what motivates learning. We learned that the Design-build activities and interdisciplinary projects help students to learn thinking and working as engineers, but also that we can still improve. We also learned that coherence between activities in different courses running simultaneously could be improved.

We work continuously on improvements of the individual courses and the entire programme. Basically, the development is based on guidelines as described in a local handbook for CDIO implementation at DTU, [3], which again is based on the general CDIO approach, [4]. Experiences with the CDIO-concept in the civil engineering programme at DTU are still few, and we have therefore chosen to work in several areas: One is the students' motivation, another is alignment and evaluation of individual courses and the third is enthusiasm of the teachers. All three areas are considered to be important for students' learning outcome. This was confirmed in the evaluation.

KEYWORDS

Learning outcomes, evaluation methods, civil engineering, students' experience, programme development.

INTRODUCTION

The CDIO study programme within civil engineering is new at the Technical University of Denmark (DTU). The first class is in their 4th semester during spring 2010. We evaluate all course activities in standard evaluations every year, but these do not evaluate semesters or even entire study programmes, [1], [2]. We initiated an evaluation of the first 4 semesters, in order to learn from experiences and to document the effect of the CDIO programme as experienced by students and teachers.

The CDIO programme was designed based on the CDIO standards, [4], and in accordance with the DTU-version of CDIO as described in [3]. The programme and the Design-build projects and interdisciplinary projects are described briefly as background for the evaluation.

The primary question we tried to answer is whether the CDIO programme as implemented at DTU helps students to learn thinking and working as engineers. That includes whether the CDIO activities provide learning in addition to the technical part of the CDIO syllabus, [4]. In order to evaluate which parts of the study programme help the most we also tried to find out to which degree the CDIO activities as formed at DTU improve motivation for studying and learning. We are in a continuous process of implementing and improving the CDIO approach in the study programme, and a very important outcome of the evaluation was to find out how to improve.

The objectives were to get qualitative feed-back to the first 2 years, to evaluate whether the CDIO activities generate learning as we expected, and how we can improve.

We designed an evaluation based on mixed methods in order to get answers from all students, and to be able to interpret the results afterwards, [5]. We used a written questionnaire with open as well as closed questions. Everybody in the class answered that one. We also interviewed a randomly chosen group of students. Some of the results were compared to results from a similar questionnaire posed to the same students in 2008 right after having had the first Design-build course at DTU, [1].

The students confirmed the knowledge about learning theory and quality of learning as it is described by [6] and also by several other authors, [4], [7], [8], [9]. Our purpose was to relate the answers to the specific courses at DTU, and use it for improvements.

We can conclude from the evaluation that the CDIO activities do help the students to learn thinking and working as engineers, but also that we can improve on that. We got many good ideas from the students, and we learned that coherence in the study programme is even more important than we expected, and that coordination of activities between courses running simultaneously should be improved.

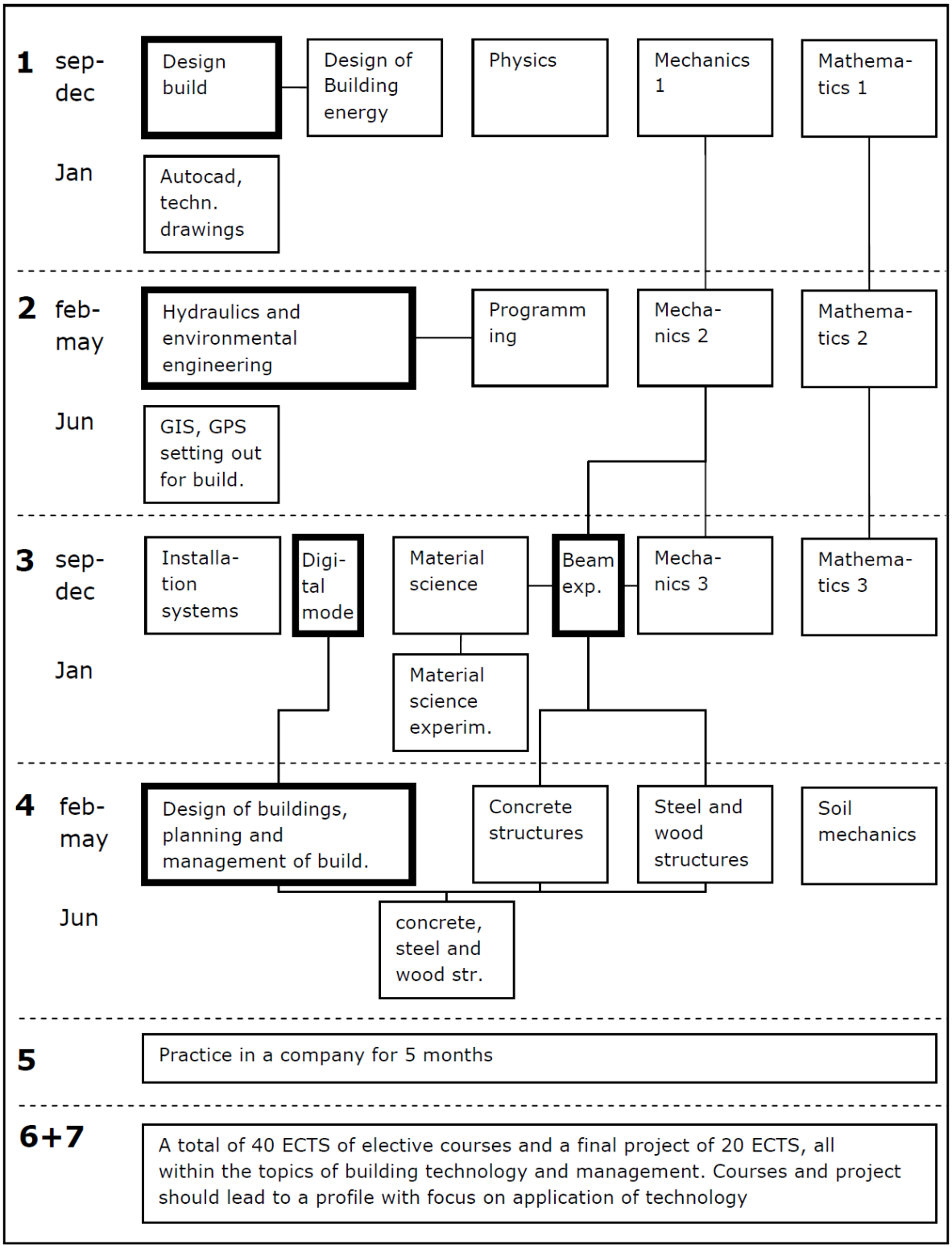

Figure 1. CDIO Programme within civil engineering. Time is downwards in the diagram indicating a sequential structure between the semesters. Each box is a course. Lines between boxes indicate simultaneous or sequential structure. Highlighted boxes include the interdisciplinary projects, including design-build projects.

CDIO PROGRAMME WITHIN CIVIL ENGINEERING 2008-2010

The civil engineering programme includes 2 Design-build projects and 2 more interdisciplinary projects in which a number of courses contribute in 1st and 2nd year. After that the students have work experience in a company for a period of 5 months. Finally they complete their education by 1 year of specialization including a final project of the amount of 20 ECTS point. The entire course of education has the extent of 210 ECTS in 7 semesters during 3½ year. In Figure 1 the basic part only (first 4 semesters) is shown in details. The courses are shown as boxes, and the structure of the courses in blocks is illustrated as far as possible. Courses of 2.5, 5 and 10 ECTS are represented and shown by the size of the boxes. Vertical and horizontal lines between boxes illustrate sequential or simultaneous structure, respectively, [4].

In September 2008 a total number of 80 students began their education to become civil engineers at the civil engineering department at DTU (DTU Byg). 6 students stopped during the first semesters, 10 students are delayed one semester or more according to the study programme and 64 students study their 4th semester in the spring 2010 with no or minor delay.

Design-Build Course – 1st Semester Autumn 2008

In the first Design-build project in 1st semester the students were asked to design and build a small house as a model of a realistic one in scale 1:20. When built the house was placed outside in November, and should be able to keep a temperature of 20 inside over a fortnight and it should be kept dry inside. All houses were placed on a plate of polystyrene in order to make heat loss towards the ground negligible (Figure 2 and 3). The students were provided with a heating cell and a data acquisition system.

They worked in groups of 4 students and had to design a house based on freely chosen focus area. This could for example be the best insulation, the most untraditional shape, alternative building materials or the most original house. When the model houses were built, the students had to operate it by measuring the heat loss for a fortnight and compare these results to theoretical calculations of heat loss. They learned the methods and theory in a course running simultaneously. The total heat loss was calculated per Kelvin temperature difference in order to be able to compare theoretical results with measurements.

Design-Build Course – 4th Semester Spring 2010

In the second Design-build course in 4th semester students were asked to design structures, installations and foundations etc. based on a project as designed by architects. The students must design structures and various elements of the house in details and verify that the design was appropriate from a technical point of view and satisfied the requirements of law. In order to do that, they built a digital model of the building (Figure 4). After designing they should plan the construction phases, make time schedules and budgets as if the project was a real project for an engineering company. The Design-build activity was related to the digital model of the buildings, by which they were able to control whether their design was coherent and they could afterwards compare their model to the model made by other groups. They were examined partly by the report, but had to present their design in an oral examination as well, and they should be able to argue for choices made during the design phase.

Figure 2. Four pictures describing the CDIO principle: conceive, design, implement and operate, from the civil engineering programme in 1st semester at DTU. Photos: J.E. Christensen and E. Borchersen.

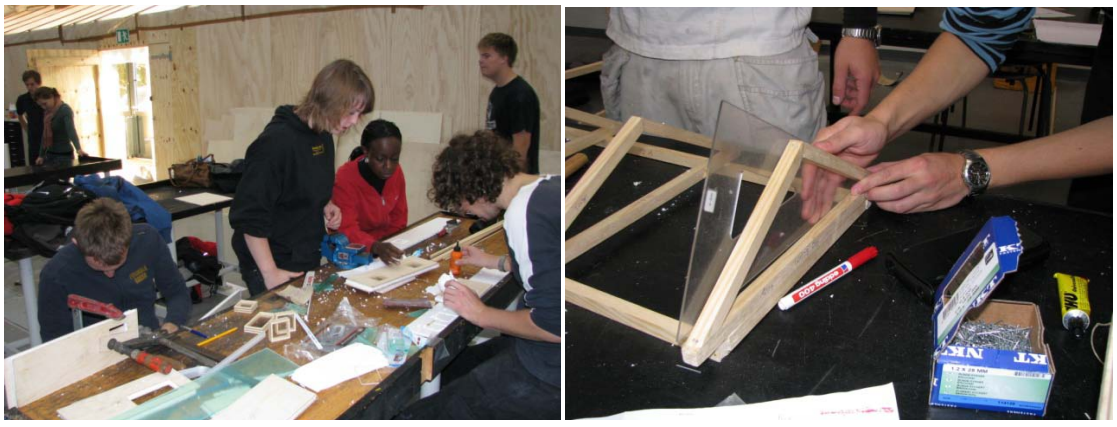

Figure 3. Students work on the model houses during the Design-build Course in 1st semester 2008. Photos: J.E. Christensen.

Figure 4. Design-build Course in the 4th semester, spring 2010. Photos: J.E. Christensen.

Interdisciplinary Projects - 2009

The first interdisciplinary project was in the 2nd semester. The students combined programming with hydraulics and urban drainage systems technology. They should design a computer program able to model the water level in an area subject to surcharge and flooding during heavy rain due to an insufficient drainage system. From the courses on hydraulics and environmental engineering they learned about flow of water in pipes and about design of drainage systems. They were provided with a series of rain data collected over a period of 30 years and a map with the relevant topography of the area and should model the flood problem based on that. They should calculate how often the location will be flooded from rain water in the future, when climate changes probably influence rains and if the existing drainage system is not redesigned.

The second interdisciplinary project was about the beam as a building component. In their 3rd semester they learned about statics for beams, material properties for concrete, steel, wood etc. and they tested a reinforced concrete beam. They controlled the bending moment by applied loads and measured deflections. They could afterwards learn from the test and compare to theory.

QUESTIONNAIRES

For 13 years, the students at DTU have evaluated each course they have attended. For 8 years this has been done electronically as a standard type of evaluation. The evaluation system at DTU has been described in a former paper at the 1st CDIO conference [1].

One of the important reasons for creating an evaluation system of the engineering education programmes is to get an idea of how well the defined goals and objectives are met. By doing this kind of evaluations year after year, it is possible to get a relative quality measure for the teaching systems for a period of years. This DTU standard evaluation takes place on course level and therefore has to be supplemented by other forms of evaluation measures in order to get a picture of how the education as a whole works.

In 2008 we asked the students to answer a questionnaire which was on course level as well (referring to the Design-build course) but served as a supplement to the standard evaluation. In

that investigation of the Design-build course focus was on the effects of the CDIO-process and we also intended a high response rate as close as possible to 100% for the students. We got that and therefore considered the answers to serve the purpose.

The questionnaire contained quantitative questions specially designed for the course as well as open questions enabling the students to make personal qualitative comments. The inspiration for and development of the questionnaire were based on personal interviews by Christensen [1] with students. The objective was to select the right questions and design the questionnaire in order to get the highest number of answers from the students, [11]. Reference is made to [1] for more details on questionnaire and answers.

Questionnaire 2010

In the present investigation the purpose was to evaluate on the level of the semesters and also on the level of the entire education programme. We asked the student in the middle of the 4th semester about their experiences so far. They were just at the beginning of their second Design-build project at that time.

The questionnaire consisted of two types of questions. On one side of the paper they should mark on a scale from 1-5 to which degree they achieved various goals. In some questions they were asked to distinguish between semesters. On the other side of the paper open questions were asked, and they also had the opportunity to write additional comments. All questions are listed in appendix 1 and also with the answers shown in Figure 5 and 6.

INTERVIEW WITH A GROUP OF STUDENTS 2010

The day before the students were asked to fill in the questionnaire we invited a group of them to a focus group interview to hear about their views and experiences. We randomly selected 12 students as a representative group among the 64 students, not too much delayed. The reason was that they should have experienced and learned from all courses in the first 4 semesters in order to be able to contribute to the evaluation. 5 students accepted the invitation and 3 more were included in the group. We invited them to an interview, in which we addressed 5 overall topics, all related to the same questions and topics as included in the written questionnaire. The questions were designed to give us a more thorough insight in their views and experiences, [12]. See Table 1. Hence, the interview was used to make the final adjustments of the questionnaire and as a supplement to the responses from the questionnaire. The entire interview lasted 90 minutes and all was audio recorded.

Table 1
Topics for group interview 2010 and typical start-up questions.

Learning strategy	How does your learning come about? Try to think about a specific situation in which you learned something valuable.
Motivation	What motivates you in your studies in general and in courses in particular?
Engineering	Did you so far learn to think and work as an engineer? And how do you expect that to be?
Coherence	Did you experience coherence between activities in each semester? Give examples.
CDIO	Do you know what characterizes a CDIO based course of education? Did you meet all 4 phases over the 2 year period as a whole?

RESULTS

Focus Group Interview

In the following the output from the interview session is referred and supplemented by some quotations from students (see also Table 1). The interview was in Danish, so the quotations represent our translation.

Topic 1: Learning strategy. The students agreed that the assessment method meant a lot to how and what they learned, [6], [7]. Examples of situations with a high degree of learning were courses with partial exams in the middle of the semester. The two main reasons for why that worked out and generated learning were according to the students themselves, that they concentrated their effort for a while and put time into it, and secondly that they made use of the gained knowledge in projects afterwards during the rest of the course, [8]. Examples of learning outcomes from projects were application of theoretical topics and teamwork.

Topic 2: Motivation. Generally and the first thing they mentioned was good, inspiring teachers, who know everything – in practice and in theory. One student said: "That I can imagine the use of it in the real world". "My curiosity and joy is basic to my study" as another student said.

Topic 3: Engineering. "Engineering is about finding solutions to problems, by searching information, choosing between different possibilities based on calculations, knowledge and judgements, and to consider whether the suggested solutions seem right", said by a student when asked what he expects engineering to be. The students added in agreement that teamwork, communication skills, project work and the ability to learn more are essential competences in order to learn being an engineer. The discussion about whether they have learned to think and work as an engineer yet was a bit more unclear. They mentioned both Design-build projects and also other projects so far – especially the interdisciplinary project in 2nd semester. Especially the teamwork competence was discussed. They preferred to work in groups formed by themselves, because they know that these groups are well functioning. They have already spent time to get things going in the groups they are familiar to, and they prefer not to spend more time on that. Some students added that the ability of forming a group and actually making the group work is an important skill which is needed when working as an engineer.

Topic 4: Coherence. A general comment was that they experienced some coherence in each semester especially related to the Design-build course in 1st semester and the interdisciplinary project in 2nd semester. They saw a good possibility to increase coherence in 3rd and 4th semesters but they also said that several courses live their own lives. Some students asked for a sequential course structure, learning one topic at a time, to prevent the situation that you need something, which you will learn later in another course. Other students asked for a better coordination between courses running simultaneously. They had suggestions to move courses from late in the study programme to earlier, because they would have liked to know something specific earlier. They were not able to point out thing that could be moved from early to late in the study programme.

Topic 5: CDIO. The students were well aware of what CDIO is, and they also found that they met all four phases during their study. As expected the operate phase is the one represented the least, and in full scale during their work experience only.

Questionnaire 2010

The questionnaire was handed out on a day where 62 out of the 64 students were present. We got answers from all of them. The results of the closed questions (1-9) are summarized in Figure 5 and 6. In the following the main results from the open questions in the questionnaire are mentioned as examples of answers.

Question 10 about motivation in the education resulted in answers like: “In some courses the topic itself is the motivation, in others a good teacher and organization of the course are the motivating factors, and finally in some courses I don’t find any other motivation than exam”. Another typical example of answer was: “Seeing myself as an engineer in the future”. These two answers represent motivational factors about how the teaching is performed and organized, what the courses are about, and why they should learn the topics.

Question 11 about learning outcomes from the Design-build projects resulted in typical answers like: “How to organize teamwork”, “I learned to solve problems”, ”How to work with a project”, “I learned to look at reality and not only theory”, “That there is sometimes more than one solution”, “Communication, teamwork and responsibility”. We got many different answers to this question.

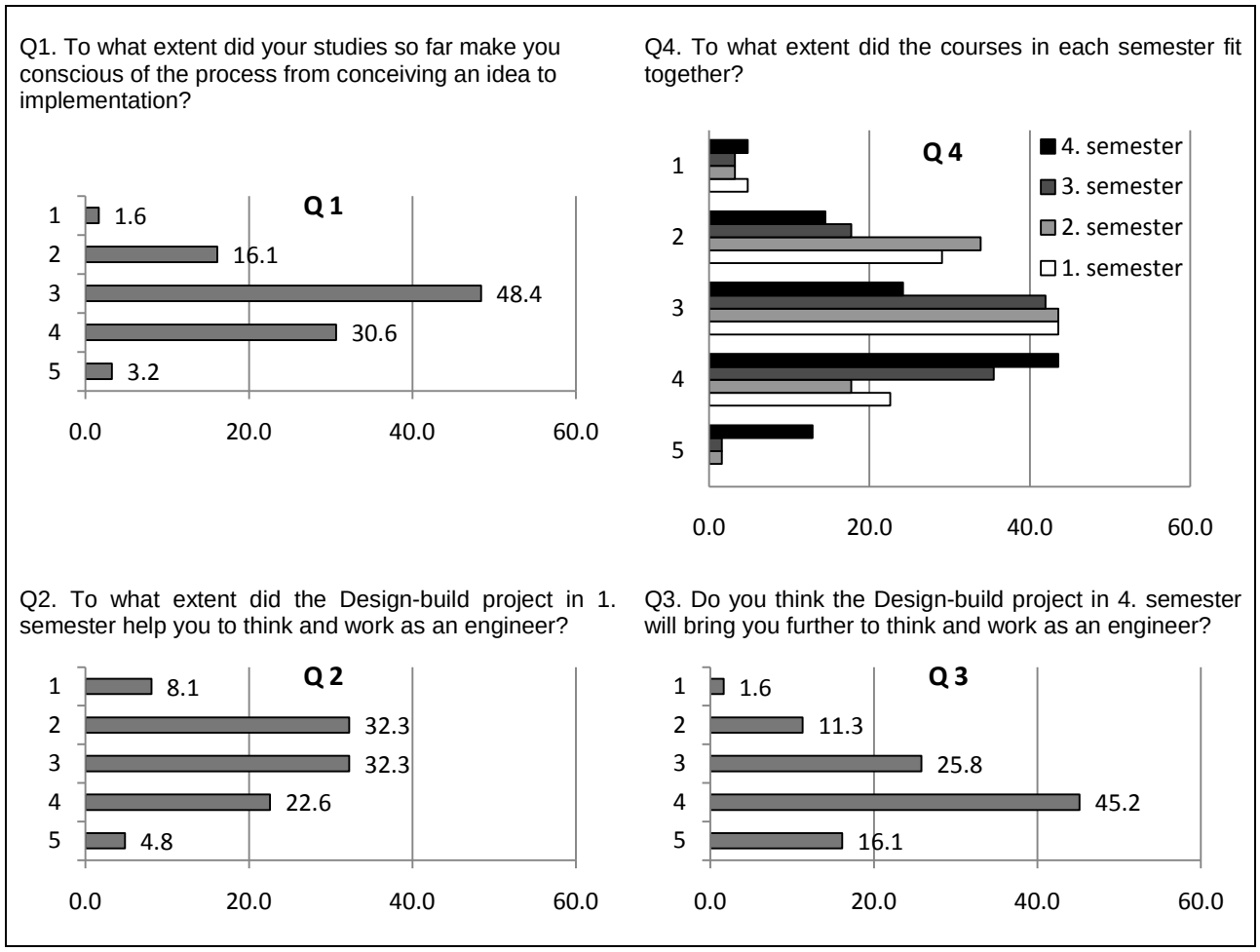

Figure 5. Results of questions 1-4 in the questionnaire 2010. Percentage of answers in the horizontal axis, and scores 1-5 on vertical axes (1 is lowest and 5 is highest possible).

Between 1/4 and 1/3 of the students answered “nothing” or mentioned technical things only (group 1 in the CDIO syllabus, [4], [3]). The rest of the students mentioned one or more learning outcomes related to especially CDIO syllabus group 2 and 3.

Question 12: “What did work well for you during your first 4 semesters?” seems to be understood in several different ways. Examples of answers are: “Classroom teaching”, “I learn a lot from projects”, “To work in small groups”, “To read and prepare for lectures”, “working with exercises”, “preparing for exams, because of the overview I get from that”, “I can contact the teachers anytime”, “Good fellow students and friends, good assistant teachers, and good study environment”, “my social life”, “second semester”. The general impression is that learning is generated, when the students are active and feel good. Lectures when serving as preparation

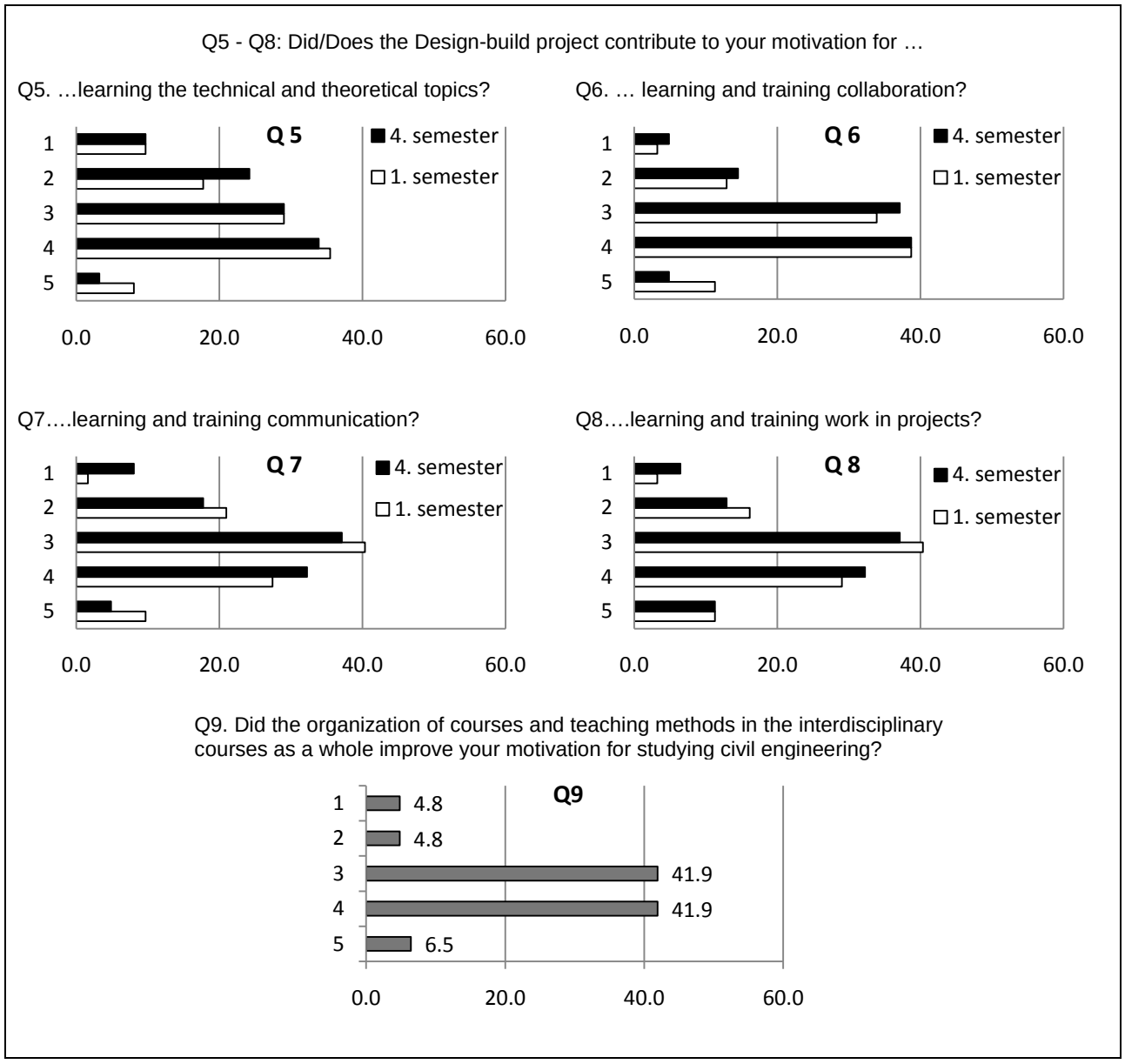

Figure 6. Results of questions 5-9 in the questionnaire 2010. Percentage of answers in the horizontal axis, and scores 1-5 on vertical axes (1 is lowest and 5 is highest possible).

for either project work or other activities in which the students should work with the topics were appreciated as well.

Question 13 asked for suggestions for improvements of the course of education. Some typical answers were: “More projects with relevance for the job as engineer waiting for us”, “pedagogical education for all teachers”, “Better coherence between activities across borders of courses and semesters”, “clear motivation for why we should learn this and that”, “Application aspects all over”, “Up-to-date material and projects”, “More CDIO”. Besides these comments we got comments on specific teachers and courses, and also specific topics they would like to learn about. These comments are valuable but not included in this study.

Question 14 was about something valuable you learned. Most of the students answered something technical from a specific course. In general they learned it because the teaching was based on active learning or from feedback. Especially situations where students were asked to come to the blackboard and explain exercises to other students, and blackboard teaching in general was mentioned. Other answers of more general type were: “Teamwork – in the Design-build project in 1st semester, where we learned that good cooperation leads to a good project”, “Cooperation – I was in a group with two other students I didn’t know, and we had to find out how to do”. “In general I think as an engineer now, when looking at buildings. I learned that from all the calculations and exercises I have been doing so far”.

Question 15 concerned whether they could see themselves as engineer in job, and why. About 2/3 of the students answered yes. Typical answers were: “Yes, I learned to find alternatives, to test my ideas, and prove that the chosen solution will do”, “Yes, but I feel unsecure”, “Yes, The most important is that we learn to learn more and to utilize knowledge afterwards”. “No, I sometimes miss the understanding of how to be an engineer. Sometimes we just get theory without learning how to implement it”. “No, I am not able to make my knowledge form a synthesis: It is like having a lot of tools but no tool box.”

The extra lines for any additional comments were typically used for elaboration of above questions.

EVALUATION OF RESULTS

Answers to open as well as closed questions in the questionnaire are in good agreement with the output from the interview. However, we got additional information compared to the interview. From the questionnaire we have the opportunity to see how most of the students feel about the different topics, without first hearing the answers from the other students. We got answers from all students – not only those who accepted our invitation, so we believe that the written answers cover more. We got the impression that the silent voices were heard. The interview on the other hand gave us more nuanced answers and a possibility to discuss the topics with the students. We did not cover as much in the interview as we did in the questionnaire. So when the two sets of information are combined we believe that we can actually conclude something about learning outcomes in the CDIO programme within civil engineering.

The overall question we try to answer is whether students learn to think and work as civil engineers and whether the study programme as implemented in 2008 help the students in that direction. We got a lot more information from the investigation, but focus here is on thinking and working as engineers and what that means.

Comparison of the Questionnaires of Autumn 2008 and Spring 2010

We compared answers to similar questions in 2008 and 2010 questionnaires about: *Getting conscious of the process from conceiving an idea to implementation,* and also *Motivation for studying civil engineering*. The answers are compared and related to other results in order to understand the outcome.

Getting Conscious of the Process from Conceiving an Idea to Implementation

The philosophy behind the concept of CDIO is to make the C, D, I and O visible and form part of the teaching frame progress. The teaching has to show a picture and authentic elements have to be brought into the teaching in the CDIO courses. In the first question in both investigations, the students were asked about the process from conceiving an idea to implementation (Figure 7).

Q1. (2010): To what extent did your studies so far make you conscious of the process from conceiving an idea to implementation?

Q1 (2008): To what extent did this course make you conscious of the process from conceiving an idea to the implementation?

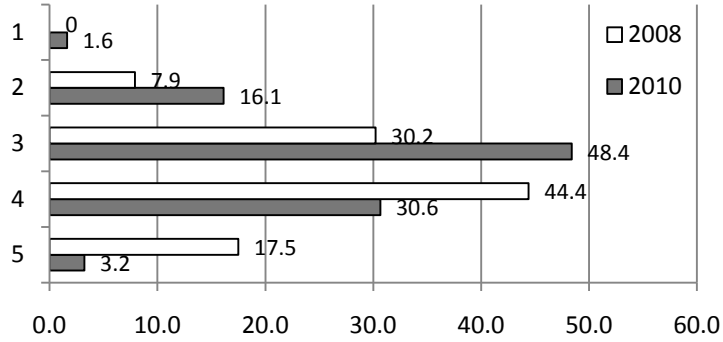

Figure 7. Results from question 1, in 2008 [1], and in 2010 – The scores are ranked from very good (positive) (5) to very bad (negative) (1)

The two questionnaires are not completely identical since all questions in the first one from 2008 referred specifically to the Design-build course in 1st semester. Question nr 1 in 2010 referred to the teaching and studies so far in general, meaning all courses and activities from 1st to 4th semester.

For this reason the two questions should not be compared directly since they are not completely identical. Even though we think the answers show that the students were significantly more positive to the CDIO concept right after 1st semester than now in the middle of their 4th semester, (see Figure 7). This is somehow not in line with the answers to questions 2 and 3 in 2010 (see Figure 5), about whether 1st and 4th semester Design-build project, respectively, helped the student to think and work as an engineer. From these two questions the Design-build course in 4th semester is evaluated to contribute to engineering thinking significantly more than the 1st semester course.

We think there are mainly two reasons for the apparent change of opinion from 2008 to 2010. One is about frustration and another about complexity: The students were in the middle of a

frustrating period, because they were in the initial phase of the CDIO project in 4th semester. After 7 weeks of input and exercises, they were now supposed to design their own buildings and they were very uncertain how and what to do. We could see that directly from the questionnaires, and that might have influenced their answers also about other courses and teaching in general. Another reason could be that answering a question about teaching and studies in general is very complex. The students probably did not refer to the same elements or activities when answering the question. We looked at the written answers to the open questions as well, and from that we could see that the 1st semester Design-build course and also many of the following elements contributed to the students' way of thinking as engineers. So when we consider the process from conceiving an idea to implementation being engineering, the students are on their way to think and work as engineers.

Motivation for Studying Civil Engineering

Integration and involvement of students in the teaching process is a well integrated part in the concept of CDIO. One point is to motivate the students for studying. This was tested in two nearly identical questions in the questionnaires from 2008 and 2010, see Figure 8.

Q9. (2010). Did the organization of courses and teaching methods in the interdisciplinary courses as a whole improve your motivation for studying civil engineering?

In 2008 the question was: Did the teaching method of the Design-build course improve your interest and motivation for studying civil engineering?

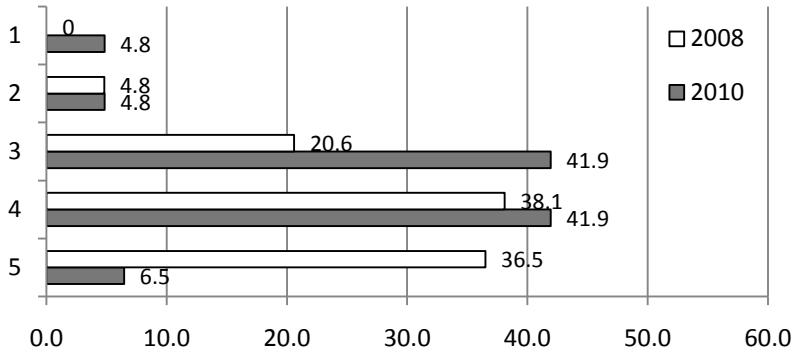

Figure 8. Results of closed question 9 in the questionnaire 2010, as compared to a similar question from 2008, [1]. Percentage of answers in the horizontal axis, and scores 1-5 on vertical axes (1 is negative and 5 is positive).

The students seem to be less motivated for studies now than they were in their 1st semester. We interpret the answers to show that they were very excited about the Design-build project in the 1st semester, and that the Design-build course was more motivating than the rest of the courses on average. Other answers we got from the questionnaire in 2010 showed that the Design-build course in 4th semester was even more motivating than the 1st semester course, but also that the students were in the middle of an uncertain phase which are supposed to have influenced their attitude to the study.

Thinking and Working as an Engineer

We addressed the topic about thinking and working as engineers in the interview and in several questions (See Figure 5 and 6). The overall impression is that the students are well aware of what engineering is, and that thinking and working as engineers include other skills than the technical and theoretical ones. The results show that the majority of the students think that Design-build courses and interdisciplinary courses contribute to engineering thinking. Most of the students could identify with the job as engineer, despite the fact that they have still a lot to learn. The students agreed that personal and interpersonal skills are required to be good engineers and that they have to practice in order to learn. The best way of learning these skills is when integrated in interdisciplinary projects, as confirmed by [8], [9].

From questions 5 to 8 (See Figure 6) we learned that the Design-build courses in 1st as well as 4th semester contribute to their motivation for learning engineering skills from all four parts of the CDIO syllabus [4]. The 4th semester course is expected to contribute the most. They evaluate the 4th semester course to motivate less than the 1st semester course for learning technical and theoretical skills and for interpersonal skills. That is surprising, and is probably because they were in the frustrating part of the course at that time. That is the impression we got from the interview.

Motivation for Studies

The results showed that the students are motivated for learning when they meet enthusiastic teachers, when the teaching is well organized, when they know why to learn, when they have fun while doing it and also when assessment is aligned with learning. The results confirm the generally accepted understanding that assessment methods have to be in agreement with teaching methods and learning outcomes, [4], [6], [7].

We can see from the questionnaire and the interview that some students found the interdisciplinary project motivating for their entire study, while others did not. The negative responses were in most cases from students most comfortable with very structured and non-surprising teaching methods, and from student not able to see the point of doing the project. The students' motivation is very closely related to their effort and their amount of time spent on studying, and they concluded themselves that they learn when they work, and they work to get results. These conclusions are all expected and in agreement with learning theories [4], [8].

How We Can Improve

When the study programme was changed in 2008 we introduced Design-build courses and interdisciplinary projects as illustrated in Figure 1 by the highlighted boxes. Almost no connections between the courses within a semester were present before 2008, whereas connections between the courses in mathematics and between the courses in mechanics were already there. The changes from 2008 were the first steps towards a better education in which the CDIO Syllabus part 2-4 are integrated with part 1.

From questionnaire and interviews the general impression is that learning is generated when the students are active and feel good. That is also in accordance with general knowledge on learning strategy [6]. Lectures contribute the best to learning when they serve as preparation for either project work or other activities in which the students shall work with the topics. We could

improve on the teaching methods in the courses not part of the interdisciplinary activities, since lecturing is still very common.

It is considered very important to visualize the coherence between the different elements in the programme. Question 4 about the coherence within each semester indicates that the students experience the highest degree of coherence in the 4th semester and the lowest in the 2nd semester. We could definitely improve on coherence in the early stages of the programme and also between the semesters. The first step would be to coordinate the activities within each semester more thoroughly. We are in the middle of the process getting semester teams to work now, and expect the coherence in general to improve due to that. We also try to include more open problems to support the students' ability to apply knowledge on new problems, [11].

We have already improved on several points since this first class of students followed the courses. Two courses in 3rd and 4th semester changed places, so that the interdisciplinary project in 3rd semester was better coordinated with the corresponding design course. A better coherence between 2nd and 3rd semester and also between 3rd and 4th semester are obtained by that change of courses. The Design-build course in 1st semester have been revised slightly every time, in order to improve the assessment methods compared to learning objectives regarding the CDIO syllabus part 2-4, [4].

CONCLUSIONS

The answers we get from students when we ask them to evaluate the courses and the first two years of study differ depending on the way we ask, [5]. We get a much broader picture and typically a better and more positive evaluation, when we ask everybody.

An interview session with a group of students gave additional information and helped us to understand the answers in the written questionnaires. Some of the questions were difficult to answer in a few lines, because of the complexity, and it could be difficult to express clearly in written form. On the other hand the interview session could not stand without the written questionnaire, since a lot more information came up than we managed to cover in the interview.

The study programme as implemented in 2008 helps students to learn thinking and working as engineers, but we can still improve.

The CDIO activities as implemented at DTU contribute to motivation for studying and learning for most students, but not for all.

The students were more positive about their CDIO-experiences right after 1st semester as compared to later.

The CDIO projects in 1st and 4th semester both contributed to their motivation for learning engineering skills from all 4 parts of the CDIO Syllabus, [4].

If coherence in the study programme is increased and especially if coordination of activities between the teachers is organized better, the programme will be improved significantly. The actual group of students was subject to the first version of the CDIO-programme, and some of the suggestions are implemented already.

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APPENDIX 1

Closed questions in written questionnaire 2010.
Rate from 1-5 where 1 is lowest and 5 is highest possible.

1.	To what extent did your studies so far make you conscious of the process from conceiving an idea to implementation?	
2.	To what extent did the Design-build project in 1st semester help you to think and work as an engineer?	
3.	Do you think that the Design-build project in 4th semester will bring you further to think and work as an engineer?	
4.	To what extent did the courses in each semester fit together?	1st semester 2nd semester 3rd semester 4th semester
5.	Did/does the Design-build project contribute to your motivation for learning the technical and theoretical topics?	1st semester 4th semester
6.	Did/does the Design-build project contribute to your motivation for learning and training collaboration?	1st semester 4th semester
7.	Did/does the Design-build project contribute to your motivation for learning and training communication?	1st semester 4th semester
8.	Did/does the Design-build project contribute to your motivation for learning and training work in projects?	1st semester 4th semester
9.	Did the organization of courses and the teaching methods in the interdisciplinary courses as a whole improve your motivation for studying civil engineering?	

Open questions in written questionnaire 2010.
Three to four open lines for question 10-15, and 1/3 of a page for additional comments

10.	What do you find motivating in your education?
11.	What did you learn from the design-build activities (besides the technical skills)?
12.	What did work well for you during your first 4 semesters?
13.	How do you think the course of education at civil engineering department at DTU could be improved?
14.	Give an example of something valuable you learned. How did your learning come about? (Think about a specific situation, and describe it)
15.	Can you imagine yourself as an engineer in a job (under the assumption that you will achieve an adequate level of theoretical and technical background before you leave DTU)? Why? or why not, what do you miss?
16.	Any additional comments are very welcome.