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A DESIGN BUILD ACTIVITY FOR A "DESIGN BUILD" COURSE

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ABSTRACT

This paper deals with the CDIO course "Design Build", which is taught in the first semester of the Bachelor of Engineering education at the Technical University of Denmark's Department of Civil Engineering. A specific design build assignment has been developed for the course, and the paper describes this course activity. The "Design Build" course revolves around the activity that the students should build a model house of their own during the course. The only demands stipulated are that the house should be made as a scale 1:20 model of a realistic house and that is should be thermally insulated and tight. The students work together in groups of four. As part of the CDIO process, each group of students should work through a conceptualization phase, where the requirements for the house are defined. Then follows the phase where the house is designed as the best possible solution fulfilling the requirements the students had set. Next, for implementation, the model house is constructed in the workshop, and the measuring system is tested and installed in the house. Finally, the house will be operated by putting it on the ground in an outdoor test field where it is exposed to the Danish climate for two weeks while the indoor temperature and heat consumption are logged. The experimental findings shall be compared to a theoretical value for the heat loss, which is found from a calculation method the students learn in a parallel course. While the course has resulted in a lot of enthusiasm among the students towards the specific construction task, it has also led to some initial frustration that the course content was not given as a well described assignment, and that the course curriculum had to be to some extent self-defined. This has been a challenge to the very young students who have participated in the course.

KEYWORDS

Design Build course, constructing, experiments, field test, group work, team building, theoretical assessment.

INTRODUCTION

The CDIO concept was introduced in 2008 at the Technical University of Denmark (DTU) as a general teaching paradigm for all students in the first two years of the university's Bachelor of Engineering program. The main goal set for starting the CDIO concept was to work on the process of reforming the B.Sc. courses with the purpose of training students to become better and more efficient engineers.

The design build activities in several educations at DTU have been described by Vigild et al [1]. The DTU model [2] includes within the first four semesters two design build projects and two other interdisciplinary projects. The 1st and 4th semester design build projects were described and evaluated by Christensen et al [3] and by Krogsbøll et al [4]. An overview of the CDIO projects in civil engineering study program at DTU is described by Krogsbøll et al [5] and the connections to teaching interpersonal skills by Christensen et al [6]. The study program for civil engineering students for the 1st semester is shown in Figure 1.

	13 weeks semester					3 weeks
	5 ECTS	5 ECTS	5 ECTS	5 ECTS	5 ECTS	5 ECTS
1	Mathematics 1	Mechanics 1	Physics	Design within building energy	Design build 1. Small house	AutoCAD

Figure 1. Study program for civil engineering students for the 1th semester [5].

The structure for the courses at DTU is with two semesters each year – either fall or spring. Each semester consists of a 13-week period prescribed for courses of a total of 25 ECTS points (European Credit Transfer and Accumulation System), a two-week exam period and a three-week period prescribed for a 5 ECTS points course, which is usually a more practical course with parts of the theory from the 13- week period put into practice. The students are supposed to earn a total of 30 ECTS points during a semester.

This paper describes the activity in a 5 ECTS point "Design Build" course, which is to be taken in the first semester at the Department of Civil Engineering, where CDIO is introduced. The course is in the 13-week period and can be in the fall or spring.

DESIGN BUILD COURSE, 1st SEMESTER – THE ASSIGNMENT

At startup, there was no method or already existing example how to teach building engineering according to the CDIO concepts. It was required to develop a design-build course for first semester students from scratch. This evolved as a brain storm process among the faculty in the CDIO planning committee. The new course should link to one of the theoretical courses, which was in the curriculum of the B.Eng. students' first year of study. This developed into the idea that the students should be given the assignment of designing, construction and testing a small model house, and for theoretical companionship, they should have focus on the aspects of heating such a house, and be able to calculate the heating requirement.

The following assignment was developed:

Conceive

The students are asked to reflect on why we live in or go to work in buildings. What kind of shelter do they constitute, and which performance requirements need be fulfilled by buildings?

The students are presented with the term “building envelope”, which in Danish translates as “klimaskærm”, or “climatic shelter”. Issues such as: protection against rain penetration, wind-tightness, thermal insulation, access to daylight, protection against burglars, being economical, visual appearance, etc. are among the themes that typically come up. When listing the performance requirements, the students shall reflect on which materials and configurations can provide the necessary functions, see Figure 2.

Figure 2. Students in the conception face pondering over the requirements from a house.

The students are not presented with any textbooks or notes for the conception phase. Instead they see a brief power point show that sparks interest in some arbitrary reasons why we live in buildings, and the students are referred to the fact that they already live in a building, and are used to going to school in one. In addition, they are invited to go on the Internet to harvest information about why and how we build. Already on the first day, the students are left with thinking of some of these issues, and they present their initial thoughts to one another on the first day. Before coming to the second lecture they should describe their home to one of their new class mates, and at the next lecture, the class mate will explain how their buildings is. This is in order to train the students to use their a priori knowledge of a vocabulary for buildings to express their thoughts.

During this phase, the students are put in group of four students with whom they should work for the rest of the course.

Design

In the second phase (after a couple of weeks), the students are asked to begin designing the buildings they will produce during the course. The building should be a model of a single family detached house in scale 1:20, replicating a house which in reality would be some 150m^2.

The students are given some basic instructions in drawing, and they come on an excursion to a construction site. It is now up to the students to discuss in their groups how should be the design of their building. They should present some alternatives, and they should express which functions the designs solve. Most important is perhaps that the students are asked to document their designs with whatever means they have learned in the drawing lessons or by means they can think of themselves. Handmade drawings, computer drawings, e.g. with SketchUp, PowerPoint shows, and textual descriptions come into play, see Figure 3.

By the end of the Design phase, after approximately some 4 weeks, the students should deliver the documentation after which they can later construct the model houses. By that time they will also have decided which materials should be used, and they deliver an order list to the teaching assistant who will then within reasonable judgement procure the materials for the students.

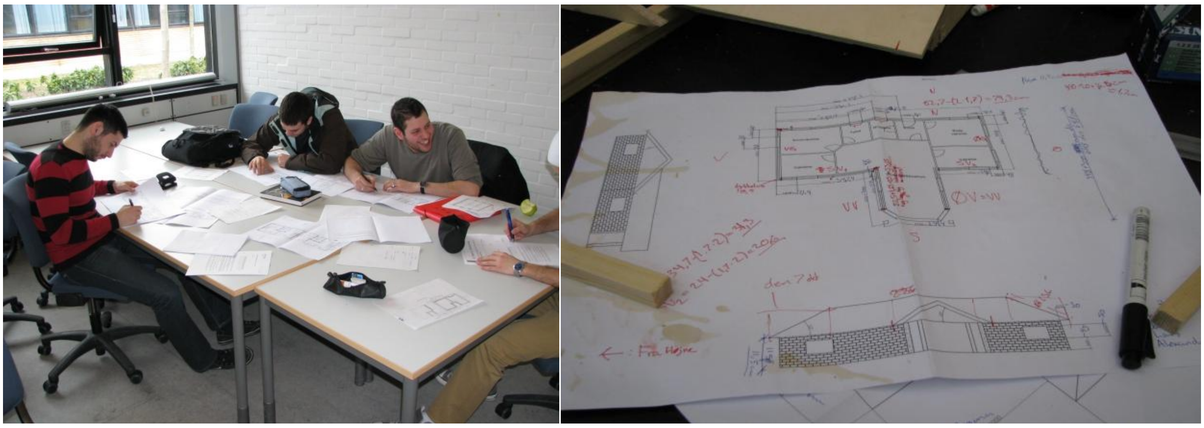

Figure 3. Students in the design face, where they design the house.

At this moment, the students have also advanced enough in the companion theoretical course, that they are now able to calculate the specific heat loss (in units W/K) of their model building by adopting the calculation rules that apply to normal buildings. These calculations are delivered along with the documentation of their design, and form a mid-term deliverable from the students. The students also present their projects to everyone in the class.

Implement

The implementation phase is predominantly an activity in the workshop. Each group of students is given a 10x60x90 cm board of Expanded Polystyrene which will form the base on which they can build their house, see Figure 4.

Figure 4. Students in the implementing face, where they built the house.

They are also given a board upon which is mounted a heating unit in the form of an 18 Ohm power resistance, an adjustable thermostatic switch, and a small fan to circulate air. The house is to be built around the control board, and on top of the polystyrene. The board comes with a wire to supply power at 24 V DC, and it has some screws on which a HOBO data logger can be docked, see Figure 5.

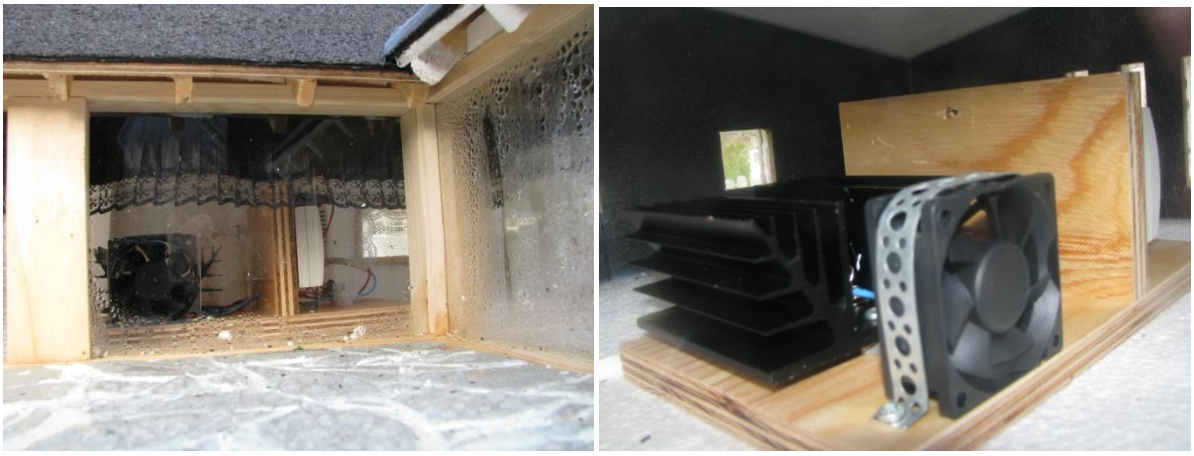

Figure 5. In the implementing face, the students have mounted a heating unit, an adjustable thermostatic switch, and a small fan to circulate air.

Apart from constructing the model house during the implementing period, the students also have to get accustomed with the HOBO-logger that each group is provided with, and to understand the basics of supplying and measuring the electric heating power that is delivered to the house. In addition to the power, the HOBO logger also measures the temperature at the control board in the model house. The students are instructed to learn the operation of these devices to such certainty that no mistakes are made in the subsequent operation phase. In that last phase they simply need to have some results in order to be able to write their final report.

The implementing phase takes around 3 weeks.

Operate

In the operating phase, the model buildings are taken outside to be tested for exposure to the real outdoor climate. We are now either in November or April. The houses are connected to the power, and thus heated to the set temperature which is being logged along with the voltage supplied to the power resistance. Together with the rated power of the small fans that circulate the air in the small building, the students can determine in 3 minute intervals the amount of heat supplied to the building. The outdoor temperature at the test site is measured at the same time. In spring, when it may get warm outdoors, the students are advised to put the set indoor temperature high so as to be sure there will be a heat loss from the building.

The model houses are tested for at least two weeks, during which time at least one alteration of the test conditions should be attempted, e.g. by turning the house so the solar gain through the windows may be different, or by making some notable (yet easy to implement) changes to the design, see Figure 6.

After the test period, it is up to the students to draw and analyze the data from the data loggers and to process them in such a way that temporal or long term average specific heat losses can be deduced. These results should come in the final report, where they are compared to the theoretical values that were determined by the end of the design phase. Most often, there are deviations between the theoretical and experimentally found specific heat losses, and the students are encouraged to comment and possibly explain such deviations.

Figure 6. The operating phase, where the students test the houses outdoors – left. The houses are connected to the electrical power – right.

The reports which are handed in are graded on the Danish 7-scale.

ASSESSMENT

For the last 14 years, the students at DTU have evaluated the courses they have attended. For the last 9 years this has been done electronically as an integrated part of the CampusNet computing and course administration system. The electronic evaluation system at DTU has been described in a former paper at the 1st CDIO conference [7]. By introducing the electronic evaluation system on the university's CampusNet, there has been opened for a detailed assessment of the evaluation data, which makes it possible to extract important information. However the negative side effect is that the students get tired of the evaluation questions of all their courses. Six courses each semester make it up to 12 evaluation questionnaires to fill in every year. The response rate varies a lot from course to course, and in many cases the response rate is rather low, which means it will not be representative.

In an investigation by Christensen et al. [3] of the Design Build course there was focus on achieving as high a response rate as possible, close to 100%, for the students attending a special teaching day where the students presented their work. The paper inquiry forms were handed out to the students, and they were asked to fill it out right away, and after having done so the forms were collected. The result from this was a 100% response rate of the students that were attending this obligatory presentation.

The paper questionnaire was drawn up as a two-page inquiry form with 16 questions on the front page and possibilities for individual comments on the reverse side of the page. The answers were ranked from very good (positive) (5) to very bad (negative) (1) to simplify the students` answers and to make it possible to quantify them.

In the following is an interpretation of some of the questions of the questionnaires from [3] will be described.

1. *"To what extent did this course make you conscious of the process from conceiving an idea to the implementation?"* – see results in Figure 7. 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 Design Build course. In the first question, where the students have been asked: to what extent did this course make you conscious of the process from conceiving an idea to the implementation? – 62% gave the score 4 or 5, 30% average 3. Only 8% gave the low

score 2 and 0% the lowest score very bad – 1. The results from this question show that the course seen from a CDIO point of view has been a great success since 92% gave from medium to the highest score.

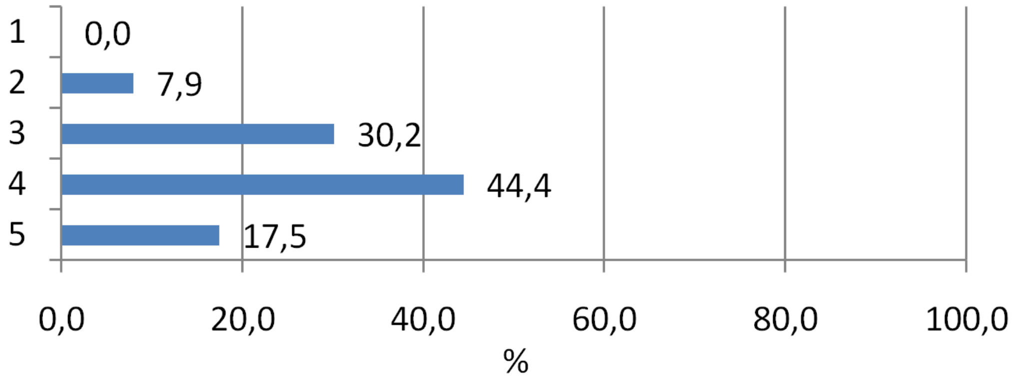

Figure 7. Results from Question 1 – *"To what extent did this course make you conscious of the process from conceiving an idea to the implementation?"*. The scores are ranked from very good (positive) (5) to very bad (negative) (1).

3. *"Did the lessons/project make you commit yourself?"*, Figure 8 – 75% gave the score 4 or 5, 20% the average score 3. Only 5% gave the low score 2, and 0 % the lowest score very bad – 1. From this it can be seen that 95% of the students find themselves committed to the project by giving the score from medium to high. This shows that the CDIO concept commits the students in the engineering education but also that the students who are maybe not so book-learned but rather prefers practical education can use the CDIO concept.

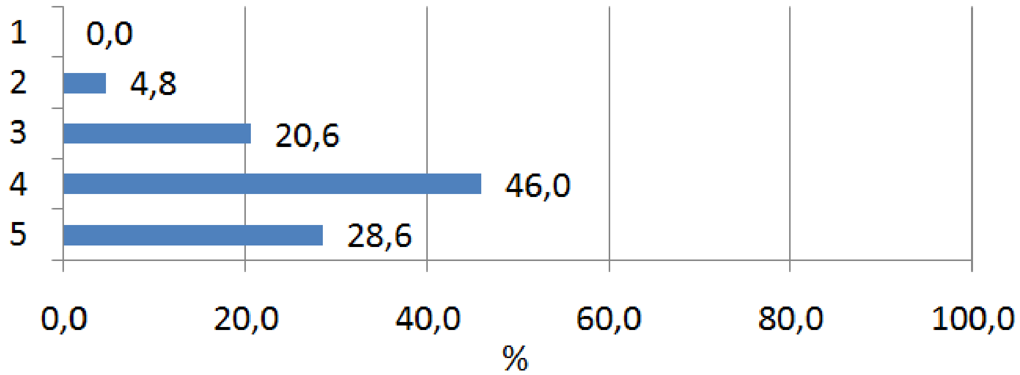

Figure 8. Results from Question 3 – *"Did the lessons/project make you commit yourself?"*. The scores are ranked from very good (positive) (5) to very bad (negative) (1).

4. *"Did the teaching method of this course motivate you for added interest in studying constructional engineering?"*, Figure 9. The concept of CDIO is to integrate and involve the students in the teaching process and make them more interested in the study. The scores show that the CDIO concept used in the course has been a success in respect to making the students interested in studying to become an engineer, since 74% of the students gave the score 4 or 5, 20% average 3 and only 5% gave the low score 2 and 0 % the lowest score very bad.

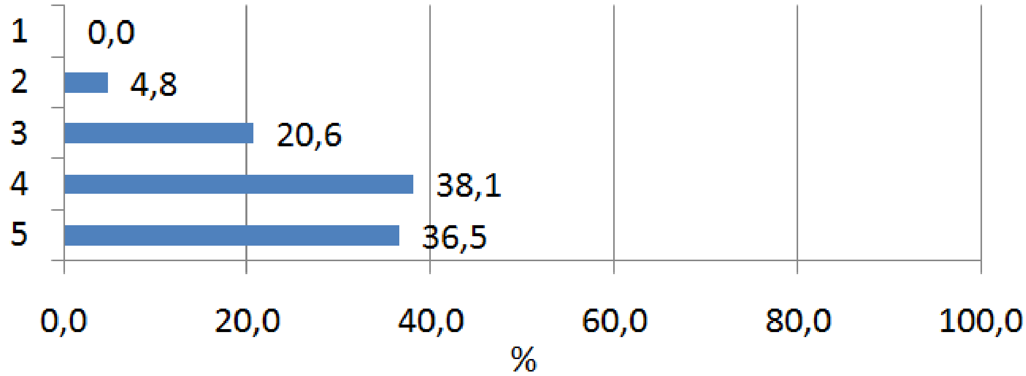

Figure 9. Results from Question 4 – *"Did the teaching method of this course motivate you for added interest in studying constructional engineering?"*. The scores are ranked from very good (positive) (5) to very bad (negative) (1).

10. *"Do you experience that the course gives you a wide introduction to engineering and studies of constructional engineering?"*, Figure 10 – 29% gave score 3, 44% – score 4 and 14% the highest score 5. Altogether adding up to 87% giving a score from 3 to 5 shows a high satisfaction. This can be an important issue for the students' decision concerning whether to continue their study to become an engineer or to change study. The answer also indicates that the CDIO course is a good alternative to the traditional teaching.

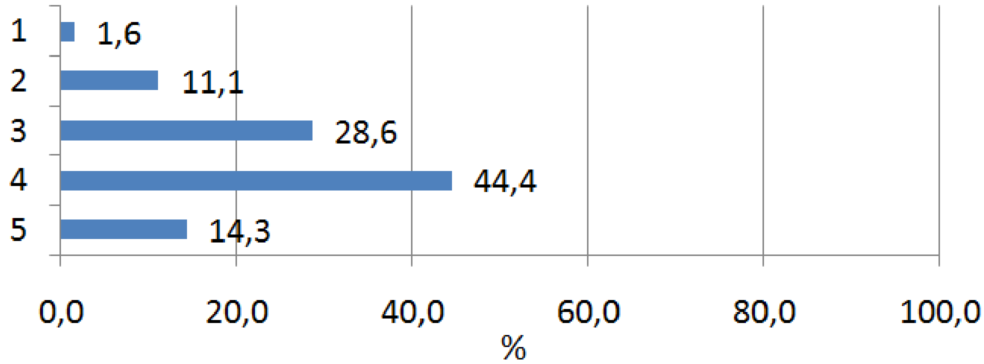

Figure 10. Results from Question 10 – *"Do you experience that the course gives you a wide introduction to engineering and studies of constructional engineering?"*. The scores are ranked from very good (positive) (5) to very bad (negative) (1).

Altogether, these four questions dealing with the "Design Build" course show a very high contentment with the course and the interactive education with personal involvement in the CDIO faces. The positive answers indicate that the students did improve on engineering skills. The students are very satisfied with the course and they recognise the idea of the contents of the course. However it has been pointed out by one student [6]: *"Especially in the process of getting to know your new fellow students, there is a lack of courses at DTU that can support these areas."* Since this is a first semester course, where the student don´t know there fellow students, it could be a good idea to improve the course by including an icebreaking part in the beginning of the course.

CONCLUSION

This paper describes an example of the implementation of CDIO as a "Design Build" course and how it has been taught in the first semester of the Bachelor of Engineering education at the Technical University of Denmark. The students express satisfaction with working together in groups in order to solve the task. In general according to the investigation by Christensen et al. [3] the results show a very high gratification with the Design Build course, and the students like the practical approach in the CDIO concept. The students are very committed and the course motivates them for an added interest in studying building engineering. In addition the course is a good alternative to the traditional technical courses [3]. However, some challenges still remain with the course: Some students feel somewhat intimidated that they have to find out so many things themselves. Based on the feedback from the students the course has been continuously improved since the start.

REFERENCES

[1] Vigild, M., Willumsen, L., Borchersen, E., Clement, K., Jensen, L.B., Kjærgaard, C., Klit, P., Sparsøe, J. "Comparison and classification of design build projects in different engineering bachelor programs". Proceedings of the 5th International CDIO Conference, Singapore Polytechnic, Singapore, June 7-10, 2009.

[2] Handbook for CDIO implementation at Bachelor of Engineering Programmes at DTU. (In Danish). Technical University of Denmark, 2009.

[3] Christensen, J.E., Rode, C., Borchersen, E. "Development of evaluation procedure for effective implementation of CDIO". Proceedings of the 5th International CDIO Conference, Singapore Polytechnic, Singapore, June 7-10, 2009.

[4] Krogsbøll, A., Christensen, J.E., Hussmann, P., "Evaluation of learning outcomes in CDIO.Programme within civil engineering". Proceedings of the 6th International CDIO Conference, École Polytechnique, Montréal, June 15-18, 2010.

[5]. Krogsbøll, A., Simonsen, C., Christensen, J.E., Larsen, T.B., Goltermann, P., Koss, H., Sand, J., "CDIO projects in civil engineering study program at DTU". Proceedings of the 7th International CDIO Conference, Technical University of Denmark, Copenhagen, Denmark, June 20 - 23, 2011.

[6]. Christensen, J.E., Karhu, M., Christensen, C., "Teaching interpersonal skills in international design-build course". Proceedings of the 7th International CDIO Conference, Technical University of Denmark, Copenhagen, Denmark, June 20 - 23, 2011.

[7] Friis-Hansen P. and Houbak N. and Klit P., "Evaluation of Course Evaluations", 1st International CDIO Conference, Queen´s University, Kingston, Ontario, Canada, June 7-8, 2005.pp 1-9.

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