INTRODUCTION TO ENGINEERING AS A TWO-PHASE COURSE

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ABSTRACT

In the engineering program at Reykjavik University we have been developing for the last four years an „Introduction to Engineering“ course for our first year students. Last fall semester we offered an introductory course in two phases: first, two days of „brain-storming“ early in the semester and then a regular intensive course for three weeks at the end of the semester, „Introduction to Engineering Design“, focusing on computer-aided design (CAD), in part based on ideas developed during the brain-storming days. In the spirit of CDIO, the two-day part was on conceiving and the three-week part on designing. As the name implies we covered design in the traditional manner, but the implicit theme was on creative thinking, open-ended projects and how the engineer can affect the environment. The project given to the students was to design a bridge across the bay in front of our campus, 400 m across, and the focus was that „a bridge is not just a bridge“ – they were encouraged to conceive of a bridge with a theme or a connection to the environment. The objectives, i.e. stimulate creative thinking and introduce some of the common tools used in engineering design were more or less accomplished. This was the first time we offered this introductory course and overall we are satisfied, but we need to improve on several things, including faculty involvement and various practical things. So yes, we will offer this two-phase introductory course again next year.

KEYWORDS

Introduction to engineering, design, creativity, CAD, open ended project, Standards: 2, 4 and 7.

INTRODUCTION

In the engineering programs at Reykjavik University (RU) we have been developing for the last four years an „Introduction to Engineering“ course for first year students. In the initial version of this intro-course we devoted one week in the middle of the first semester to a joint project. We called this „Disaster week“, the students had to react fast and design a plan on how to cope with a sudden catastrophic event (Saemundsdottir et al., 2012). We wanted to expand this course and take advantage of the semester structure at Reykjavik University, in which four courses are taught concurrently for 12 weeks and then one intensive course for 3 weeks.

CDIO standard 4 deals with the benefits of teaching an introductory course that introduces essential personal and interpersonal skills and also introduces students to engineering methodology, thereby providing a framework for engineering practice. CDIO standard 2 deals with the importance of learning outcomes being consistent with program goals and validated

by program stakeholders. In addition, standard 7 refers to integrating learning of disciplinary knowledge with personal and interpersonal skills. During the academic year 2013-2014 we spent quite some time interviewing stakeholders (Matthiasdottir et al., 2014). Their views regarding the importance of developing students' skills in teamwork, project planning, efficient use of logbooks, awareness of professional ethics and presenting the results of their work came through loud and clear. We felt that integrating these topics into a course that had previously been a very classical CAD course would be a good way to improve our programs.

In the fall of 2014 we developed and ran an introductory course in two phases: first, two days of „brain-storming" early in the semester and then a regular 3-week course, „Introduction to Engineering Design" at the end of the semester, with the participation of about 160 engineering students. The main focus of the 3 week course was on computer-aided-design with the students working with the ideas they had developed during the brain-storming days. In the spirit of CDIO, the two-day brain-storming part is on conceiving and the three-week part is on designing. This introductory course is mandatory for all first year students in engineering, including biomedical, civil, electrical, financial, mechanical, mechatronic and industrial engineering.

In Figure 1 we outline the structure of the first semester in engineering at RU: for the first 12 weeks all students take concurrently four traditional courses focusing on knowledge and skills, then there are 2 weeks allocated to assessment and for the last 3 weeks of the semester students take one intensive course, Introduction to Engineering Design, focusing on computer aided design, engineering design and interpersonal skills.

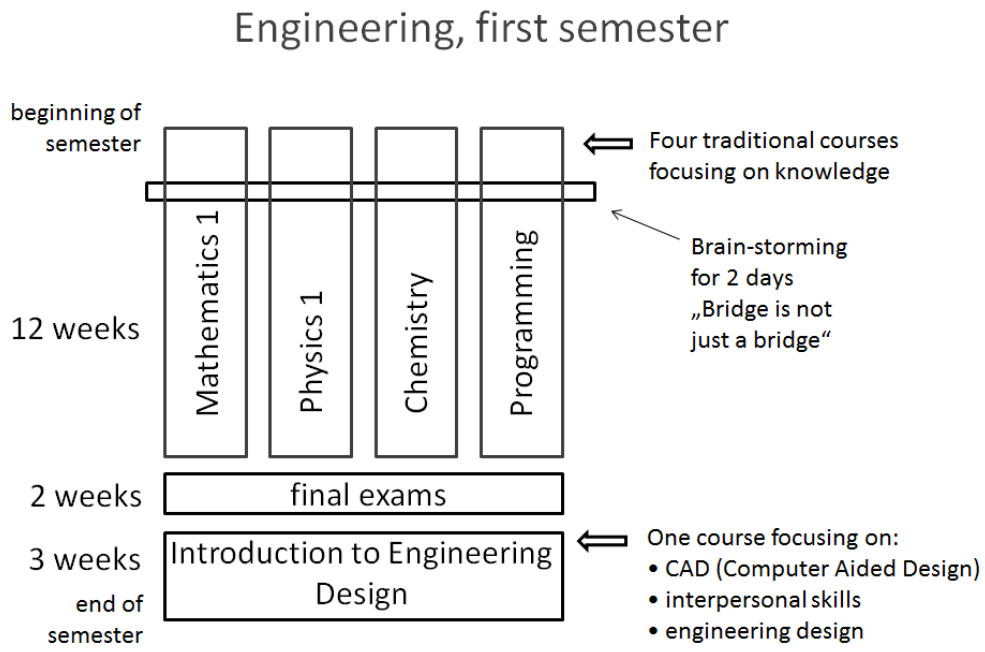

Figure 1. Outline of the first semester in engineering at Reykjavik University. For 12 weeks all students take concurrently four traditional courses, then 2 weeks for final exams and finally an intensive course for 3 weeks.

IMPLEMENTATION OF THE TWO-PHASE INTRODUCTORY COURSE

Brain-storming days

In the fourth week of teaching in the fall semester the students got a break for two days, which we refer to as brain-storming-days. The start-up was late afternoon Wednesday with a brief presentation of the task at hand, and there was quite a bit of anticipation in the group as they did not really have a clue about the project. The project presented to the students was to design a bridge across the bay in front of our campus, 400 m across. The theme was that „a bridge is not just a bridge“! A bridge might be a landmark, a theme park, an artistic landscape, under the sea, and it might serve other purposes than only the transport of people – so the students were really pushed to think outside the box and possibly conceive something unexpected.

On Thursday morning a well-known artist gave a brief inspiring presentation on the difference between practical engineers and lofty artists, and on the dynamic synergy when individuals from these two domains work together. Thus emphasizing that an engineer may need to be open to creative solutions when facing and solving unusual challenges. Then we introduced the students to a formal method of brain-storming, a method each group used to reach a consensus on the main theme of their project. The students were introduced to cases which showed that this method of brain-storming is widely used by companies that focus on innovative engineering solutions and product development, companies that have done well financially and the students see as “hip and cool” for seeking employment to advance their careers. This definitely served to motivate the engineering students. The students worked in groups of five or six, a total of about 30 groups. At noon all groups had reached a consensus on their ideas and after lunch the groups started creating a model of their bridge-related idea. Actually, we left it up to the students how they would present their final idea, be it a drawing, computer animation or an actual model made of wood. To our surprise, by far most of the groups created a model out of paper or balsa wood, and were eager to use colours – they were much more artistic than we had anticipated that students of engineering would be. Moreover, the students were really into this and worked very well.

At noon on Friday all groups presented their ideas in the main hall of the university, most of them by displaying models. A small group of faculty and the artist evaluated the presentations, and three groups were awarded prizes, thereby concluding these two dynamic days.

The faculty was generally satisfied with the brain-storming days, the students put great effort into finding creative solutions and they worked much harder than we had anticipated. When evaluating the event many students mentioned that they liked being able to do something totally different from regular study and that they got to know their fellow students much better. In short, this two-day event turned out to be a great success.

Introduction to engineering design

The latter and main phase of this introductory course, “Introduction to Engineering Design” ran for three weeks. During the first week students focused on learning to use CAD software, i.e. AutoCAD, Inventor and/or Revit, which was the main objective of the course. In the following two weeks they used the software to design the bridge they had worked on during the brain-storming days, again in groups of five or six students. Secondary objectives were to

introduce students to project management, teamwork, ethics, video-making and proper use of logbooks. We put emphasis on encouraging creative solutions in their designs. Total of 160 students, in 29 groups, were active in the course. Table 1 lists the learning outcomes for the course.

Table 1. Learning outcomes of the course Introduction to Engineering Design.

On the completion of the course the student should:

• be able to use computer aided design software in engineering, i.e. AutoCAD and Inventor (or AutoCAD and Revit for students in civil engineering)
• have applied engineering methodology, including project management, in the design process
• have had introduction to projects in her/his field of study
• have received training in teamwork and understand the importance of cooperation and diversity in a group
• know how to present ideas and designs by using technical drawings, posters, videos and models
• be able to use a logbook effectively

As the course is only 3 weeks it needed a well thought out organization, starting with teaching the necessary basic elements of CAD and project management to prepare students for the design work. Lectures on the use of the CAD software were made available to the students on-line, so the main focus of the teachers work was to assist students individually or in small groups. To complete this first part of the course each student had to complete exercises in CAD and turn them in; the bridge theme came later. A turning point in the course was on the seventh day when students attended lectures on agile project management, team work and using logbooks. Also at this point students began their group-work and the planning of their design work, working in the same groups as during the brain-storming days. Along the way students had one lecture on video-making and two lectures on ethics in engineering. The teachers that taught CAD were available to the groups while working on their design and the teacher that introduced them to video-making was also available for discussion. Table 2 shows the timeline and tasks of the three-week course.

Table 2. Outline of the three-week course Introduction to Engineering Design (15 days).

3 days: 3 days:	• Introduction • Learning how to use AutoCAD • Learning how to use Inventor (or Revit) → *each student turns in the assigned exercises in CAD*
1 day:	Lectures on: • Agile project management • Use of a logbook • Teamwork Students tasks: decide on the bridge project
7 days:	Lectures on: • Ethics in engineering • Video-making Students' tasks: design using CAD and regular consultation with engineering faculty
1 day:	Wrapping up and presentation: → *each group turns in their design: poster, CAD drawings, logbook and a 2 minute video.*

Five faculty members were assigned groups of students according to their field of study, each advising two to eight groups. Each faculty member consulted with his/her group once or twice a day. The design project was semi open-ended, and the only requirement was that it´s theme was a bridge across the bay, and preferably a continuation of the work the students had done during the brain-storming days. At the completion of the course, each group presented their design, their logbook and a 2 minute video on their work and design. This final event was again held in the main hall of the university, and served as a pleasant conclusion to the students' first semester.

RESULTS

One objective of this two-phase event was to get students into creative thinking by finding creative solutions to what might appear to be a mundane project, building a bridge across a 400 m wide bay in front of our campus. Another objective was to introduce them to some of the common tools used by engineers, i.e. computer aided design, project management, teamwork and presentations. The purpose of doing this in two phases was to get students to really let go in the first phase and brain-storm for two days, the more creative the better, and think more about the theme of the bridge-project rather than the bridge itself. The ideas then lurked in their minds for two months or so. When they began the latter phase of the project, they had possibly reflected on their ideas, and were hence better prepared for designing the bridge.

The 2-day brain-storming phase of the introductory course worked very well and we accomplished what we intended to do: stimulate creativity and students experienced the benefit of teamwork and got to know better their fellow students. End-of-Course survey showed that the students were generally very satisfied with the course. Discussions with the faculty revealed that they were quite pleased with the outcome of this phase of the course.

In the 3-week design phase we successfully introduced the students to the fundamentals of CAD in design, the use of logbooks and how to create structured short videos. The aim of the video was to teach the students to present the results of their work, to “sell” their ideas whether it be the design of a bridge or some other concept. Students got to know the faculty much better than was possible in the large classes earlier in the semester. During this design phase, several students felt frustrated or overwhelmed by the open-ended project. The idea was that the faculty would serve as consultants in aiding the groups, meeting the groups once or twice a day, and for most groups that worked very well, but in a few groups students needed more guidance than they received. End-of-Course evaluation for the 3-week design phase showed the students to be a little ambivalent, they liked to work on a design and learn to use CAD software, but many of them stated that the project was too open ended and they would have liked more guidance. The faculty, as discussed at meetings and informal discussions, overall liked the course, but suggested that the projects for each group should be more manually steered towards the interest and discipline of the group. Teamwork was assessed by faculty only this time. When we offer this introductory course next year we need to prepare the faculty better and dwell more on what is expected of them.

CONCLUSION

To stimulate creative thinking and teach the use of some of the tools most commonly used in engineering (see Table 1) were the objectives of this two-phase course, and we feel we accomplished that more or less. Splitting the course in two phases appears to be beneficial, it improved the students’ experience and it gave the students some time to reflect on the ideas generated during brain-storming-days before starting the design part. This was the first time we offered this two-phase introductory course and overall we are satisfied. We achieved most of our objectives, but we need to improve on several things, including faculty involvement and some practical things. Yes, we will offer this two-phase introduction again next year.

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BIOGRAPHICAL INFORMATION

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