A INNOVATIVE ENGINEERING SUMMER SCHOOL V2.0

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ABSTRACT

This article describes a summer school which focuses on a conceive-design project. The summer school has been run three times; each of the implementations is described. The last implementation (v2.0) is discussed and four challenges are identified and discussed in detail: assignments, the role of the teacher, secondary students as trainees and cultural differences. We discuss challenges to the summer school, if it should held be in a traditional institutional setting.

KEYWORDS

Multidisciplinary engineering; innovation; industrial setting; soft skills conceive-design project.

INTRODUCTION

In an increasingly globalised world, it is vital for any company that its employees are capable of creating innovative concepts for new products and for the subsequent production process faster than today. In addition, the complexity of products tends to increase continuously. In order to master that complexity and at the same time produce these products faster, it is essential that engineers with different disciplinary and cultural backgrounds are able to collaborate efficiently. In general, there is a significant demand from industry for engineers who can collaborate with stakeholders outside their own discipline. This is in contrast to the dominant educational setting of today. Almost all of the students' learning is focused on their specialist discipline.

The article is structured as follows: The first section describes the first version of the summer school – a "proof of concept" instantiation. In the next two sections, we describe the first two instantiations, the principles behind the design and the actual realization. In the following section, we identify, describe and propose solutions to some challenges with the design. The subsequent section discusses how to integrate the main ideas of the summer school in a more traditional institutional setting. The last section is a conclusion.

A SUMMER SCHOOL V0.0

Before engaging in a fully fledged summer school for three weeks and up to 30 students a small pilot version of it was delivered. This was a one week intensive event with five students from VSB - Technical University of Ostrava from the Czech Republic and five students from Aarhus School of Engineering in Denmark. This first version fully focused on innovation aspects since it was felt that this was the aspect most underdeveloped with these engineering students. This prototype was a success where most of the students got new eye-openers in the areas of innovation and multi-disciplinary collaboration. However, this prototype of the summer school also gave valuable input about in particular the logistics of the full scale of the event. It was also concluded that the interfaces between the different engineering disciplines should be given more serious attention and that an industrial design competence would nicely complement the engineering skills. Finally, lack of sufficient skills of the English language was identified as a barrier to success and this information was used in the selection process for the students to attend the first real 3 week summer school.

A SUMMER SCHOOL V1.0

A group of six European institutions, in collaboration with an industrial company, had organized a summer school, entitled ‘Conceptual Design and Development of Innovative Products’, in order to prepare the students for the globalised world. The summer school, which brings innovative dimensions to higher education, was conceived taking into account the following essential principles:

- <u>Innovative</u>: the students should design new, pioneering products
- <u>Team-oriented activities</u>: the students work collaboratively in teams to develop an engineering product.
- <u>Multidisciplinary and multicultural approach</u>: the teams are composed of students with different disciplinary backgrounds and different countries, whose skills, knowledge, and experience are important to combine in order to achieve the project’s goal.
- <u>Coaching</u>: The teachers should coach rather than teach the students.
- <u>Intensive schedule</u>: the summer school lasts for a relatively short period of time, and students work exclusively on their projects during five days a week.
- <u>Industry-oriented</u>: the summer school takes place in an industrial setting and the assignments shall give the industrial partner ideas for new products.

The original pedagogical design is briefly described in [1].

The three-week programme was divided into three stages, during which the students had to accomplish several tasks in order to conceive an innovative product concept. The stages are as follows:

- **Stage 1**: students practice and expand creativity and teamwork skills;
- **Stage 2**: students elaborate on the idea of a concept for a product; and
- **Stage 3**: students work on the product, namely on its prototype, its design, and its technical documentation.

The first week focused on creating an idea for an innovative concept for a mass-market product, by using creativity, and on developing a proof-of-concept. The remaining two weeks took that concept and prototype forward to the point where the actual production process for the product could start to be prepared. In this period, different disciplinary analyses were conducted and, in particular, the interfaces among the different disciplinary parts were agreed upon and described precisely.

The programme also included time for some social events, which were deemed important to build social links among all participants of the summer school. Those events took place preferably during the evening hours and during the weekends.

The assignments given to the students were more open-ended than in particular what the engineering students was used to. This could for example be an assignment for coming up with a new portable radio concept that would appeal to the young generation whenever they appear in groups for example at beaches or in connection with sport events. However, it was felt that it would be advantageous to make the assignment more open ended to challenge their creativity skills even more (see later).

A SUMMER SCHOOL V2.0

The general structure for the three week programme from the previous year was kept although minor adjustments optimizing the experience were incorporated in the detailed programme. The assignment was made more open ended so it could for example be a matter of coming up with an experience in the outdoor area in the warmer areas of the world. This definitely had the desired positive effect on challenging the creativity of the students. However, this also had the side effect that some of the students felt that they came outside their own comfort zone and in the process of cutting alternative innovative ideas into one personal ownership feelings of the ideas meant that there was need for more assistance from the teaching staff ensuring a successful conclusion on this heated discussions. This also had the consequence that the teacher team felt the need to move more students between the groups after the first week to optimize the success chances both at the group level and at the student level

IDENTIFIED CHALLENGES

Based on evaluations from the students, feedback from the industrial partners and an interview with one of the founding teachers, we have identified the following four challenges with the implementation of version 2.0:

- Assignments did not lead to new, pioneering products
- The role of the teacher
- Secondary school students as trainees
- Cultural differences

In the following four subsections, each of the challenges will be described and possible solutions discussed. Each of the subsection ends with a suggestion for a design criteria.

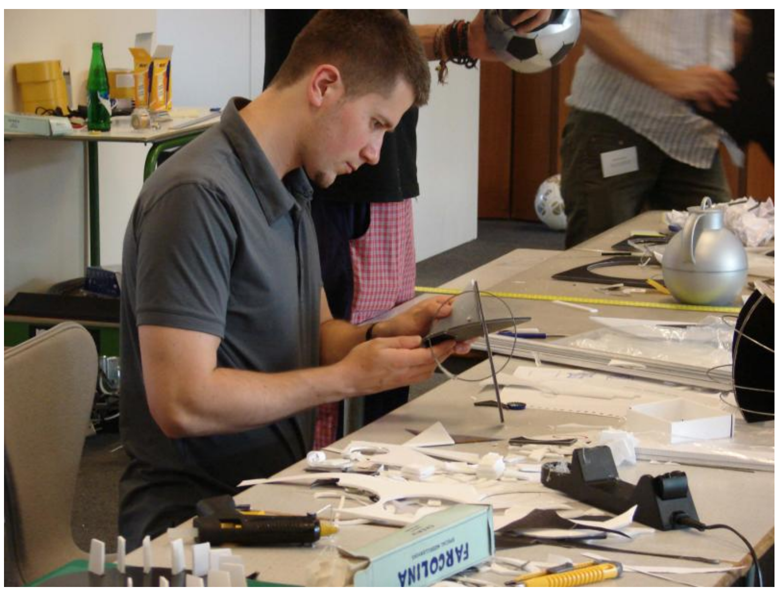
Assignments

The main purpose of the assignment is to give a direction and frame for innovation. The assignments had the form “solve this issue” (e.g. a new portable radio concept for young people). The problem with this was that the students found it difficult to “think out of the box” and their solutions did not give raise to new product ideas but refinements of current ideas. As Heer et al [2] writes “Innovation needs a few things in order to exist or be used and learned. … If a student is given a particular task to do and provided all the detail of how to do it, why should they even consider another method?” (p. F1A-11)

In order to make the students more innovative, the assignment was changed to a more open one. The task could for example be “create something for a sound experience in the garden”. This led to more innovative and different ideas, but it had the negative impact that there was a much higher feeling of ownership to ideas. This led to frustrations and it was difficult for the students “to let go” of their own idea. At the end of the first week the students had to decide what the ideas were they will pursue in the following two weeks. Here it was much more difficult to agree in the group and as a consequence more conflict resolution for the teachers.

With a more open ended assignment, the industrial partners disagreed more. The students got feedback from several people from different departments, each having different goals and agendas. This is typically not the case in a traditional course, where the students get feedback from just one teacher, and the attitude is “what the teacher says is correct”. In this way, the students see many of the problems in conceiving, designing and implementing systems in an enterprise – it is not always the technically best solution, but the one that can fit as a compromise.

The industrial partner found the solutions more interesting than the one from version 1.0. They do not expect the students to come up with a product that they directly can put to the market, but the more open assignment led to products where part of the solution could be a part of a future product. The students did not expect their product to part of the product-portfolio of the company, but with an increased interest from the industrial partner, the students were even more motivated to work on their project. One teacher formulates it this way “wow - they [the industrial partner] is interested in some aspect our idea, so what we have been thinking is in the right direction”



In general we conclude that it is better to give more open-ended assignments if the purpose is to raise the level of innovation. On the other hand it is necessary to give some directions (e.g. “an experience in the garden” with the unspoken requirement that it has to do with the area of the industrial partner) to ensure the focus of the innovation.

The Role of the Teacher

Traditional teachers from the institution have a strong focus on research and teaching their field in a traditional institutional setting. In this course, the role of the teacher is more like a coach than the traditional subject area expert. As described previously, the more open-ended assignment gave rise to more conflicts between the students.

CDIO schools have design-implement projects, and many other engineering schools have projects as a part of the portfolio of teaching methods. This gives raise to the discussion: “How do we form student groups?” In the area of computer supported corporative work, there has been intense research in this subject. Due to the fact that students are in different geographical

Figure 1: A student working on his concept

locations, the concept of a CSCL scripts (or collaboration scripts) have been invented [3, 4]. One of the most well-know scripts is the Jigsaw, where each group member has only access to a subset of the information necessary to solve the problem [5]. This script was used to help the students to get to know each other in this course. CSCL scripts make the criteria for e.g. group formation very explicit. In traditional project, the typical criteria is friendship, since the typical group formation principle is “let the students decide for themselves”. This traditionally hinders a lot of conflicts. In this course, the students were grouped by the following criteria:

- Field of expertise/study
- Country
- Sex

As a consequence, there are more conflicts that the teacher needs to handle than in a traditional course. It is more important to have efficient coaching skills; skills that many traditional teachers do not have.

In the first week of the course, there is no group-leader. At the end of the first week, a leader for each group is selected. The students tell the teachers if they want to become group leader. All students in the group point out the person they think will be the best leader. If all the students in a group points out one, she is chosen. If more than one person is suggested, the teachers discuss and choose among the suggested students.

The teachers for the course were solely picked by the institution, mostly on the basis of their professional area. It was not possible to give guidance in order to select teacher who were experts in conflict resolution. In the future this will be given higher priority and we want to ensure that at least one teacher has conflict resolution competences.

In general we conclude that it is very important to have at least one teacher with good conflict resolution competences; and it is important to have this as a criteria on at least the same level as the teachers expertise in a given subject area.

Secondary School Students as Trainees

All of the participants are on the same educational level (e.g. all students are in their final year of their bachelor's degree). To mirror the typical industrial enterprise, it would be nice to have persons with different levels of competences. In the summer school v. 2.0, secondary school students were invited to be part of the project. The purpose for this was three folded. Firstly, they could take part in the creating of artifacts (e.g. a modeling wax model of the idea, soldering an electronic prototype) and thereby contribute to the product. Secondly, the high school students will get a much better understanding of what an engineer do and what engineering education is. Taking part in a multidisciplinary project will furthermore give them a good insight in the different engineering field. The will be able to answer the question "if I want to be an engineer, what type of engineer do I want to be?" in a much more qualified way. Thirdly, the engineering students will enhance their communication skills and be able to explain to a non-peer what their subject area is about.

Engineering students are schooled. This can sometimes hinder innovation due to the fact that they focus on all the practical barriers in an idea. Secondary school students can have a more open-minded approach to ideas and thus raise the innovative quality.

Unfortunately, we were not able to attract secondary school students. At the local upper secondary school, there is a science class form which we expected to attract students. We did not market the possibility very well; hopefully we will be able to attract secondary school students this year.

In general we conclude that it might be a good idea to include students with other qualifications than engineering students in order to enhance the engineering students' communication and collaboration skills.

Cultural Differences

The Scandinavian culture is quire independent Students are used to discussions and project-work and not to see the teacher as a "god" but as a resource with whom they can discuss both subject area and process problems. This is not the same in Southern- and Eastern Europe. Here the teacher is an authority which the students cannot discuss with. This can be a problem, since the project is based on the fact that students by themselves figures out what tasks the must work on. Many Southern- and Easter European students are used to wait for the next task to be assigned to them.

The project leader is elected at the end of the first week (in the innovation week it is expected that the tasks for the group is not as easy to distribute hence no leader is needed). Typically, the project leader comes from Northern Europe. This is not in itself a problem, but more an observation. All students learn a lot from the cultural differences – about another culture, but also about their own, since many of the things they take for granted suddenly has to be explicitly communicated to the other group members.

All of the students get an understanding of the issues in a globalised world – they get used to take many implicit values into account when making decisions and communicating.

To speed up the focus on cultural differences and thereby making it more explicit to the students, they participate in a team building activity the first day. In this exercise, the students see the entire process from idea to prototype based on a simpler problem. In the first week, the students furthermore build part of a Lego town. They are placed in three groups, one group have to build a house, one a helicopter and the last group a garage. The students are given a limited amount of bricks, so that they have to collaborate and communicate to solve the task. A developer – a teacher – decides if the proposed solutions are acceptable. It is an experience for the students to find out that it is not enough to solve their own task, but they have to negotiate with the two other groups to solve the task together and to structure their time to achieve the goal.

As a side effect, the students establish an international network. After the course, many of the students keep in touch and discuss both personal and professional issues.

In general we conclude that it is very important to create groups that have country as a parameter to ensure that the students learn about cultural differences and thereby prepare them to a globalised working environment.

INTEGRATION IN A TRADITIONAL INSTITUTIONAL SETTING

The described course is a summer course done in an industrial setting – how can we transform the ideas and implement it in a more normal educational setting?

Many have described design-implement projects on their own institutions [6, 7].The addition here is the focus on innovation, the intense planning, the different cultures and the collaboration with industry. All of these can more or less easily be incorporated in a traditional design-implement course in a university.

Traditional courses are typically taught by one or more teachers within the same subject area. One of the important design issues in this course is the fact that students get conflicting answers. Let teachers take different roles in the project in addition to their subject area expertise could be one suggestion if one wants to achieve the same in a more traditional course.

One of the problems in the setup for this summer school is the fact that the teachers do not know each other very well on beforehand. They tend not to have knowledge of the other teachers competences and subject areas. We believe this could be easier if all of the teachers come from the same institution. Then the collaboration could start well before the course and the teachers could have a better understanding of each others' competences and subject areas.

In many universities teachers have office hours. When students get ideas and have questions, it is important that they can get a response quite quickly. We suggest that teachers give up their office hours and let students see them when they want.

The fact that the students learn about different cultures is harder to mirror in a traditional university. At the engineering college in Aarhus, our students have successfully cooperated with students in United Kingdom in the following setup: In the beginning they meet for three-four days to get acquainted with each other and to have the innovation phase. Then the students collaborate back in their home institution for the next two – three month using different electronic communication facilities. In the end they meet again for three – four days to wrap-up their prototype. This could be expanded to more countries to allow for more cultural learning.

Traditional institutions have a semester or quarter structure, so it is not easy to have as intense a course as this summer school. Our students scheduling algorithm with respect to work is normally "earliest deadline first". This could have the effect that a project like this would only get attention in the end of the semester/quarter. To avoid this, we suggest that several deadlines are part of the course. The innovation week could take three weeks with 1/3 load. After these three weeks the students select a project leader who has the responsibility to make a project plan with several milestones and deliverables. Other institutions do not have the same schedule each week then it could be possible to have an intense, three week course.

CONCLUSION

We have described the first three implementations of a summer school which focus on a conceive-design project in an industrial setting. Based on this description, we have identified four challenges: assignments, the role of the teacher, secondary students as trainees and cultural differences. Each of these challenges was discussed in detail. We discussed challenges if the course should be in a traditional institutional setting.

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Biographical Information

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Peter Gorm Larsen is currently a professor at the Engineering College of Aarhus and in addition he holds an adjunct professorship position at the Aarhus University. After receiving his M.Sc. at the Technical University of Denmark in Electronic Engineering and Computer Science in 1988, he went to industry to bridge the gap between academia and industry. He later returned and did an industrial Ph.D. which was completed in 1995. He gave industrial courses all over the world, and had an industrial career until he decided to return to academia in 2005. His prime research interest is to improve the system engineering requiring cooperation between multiple disciplines to determine the optimal solution. He is the author of more than 60 papers published in journals, books and conference proceedings and a couple of books.

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