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MANAGING MULTIDISCIPLINARITY – GROWING FUTURE CREATORS

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ABSTRACT
Preparing students for real life is a main issue for education programs. At Luleå University of Technology, (LTU), this is done by a range of different course layouts and course assignments. Students studying at the Industrial Design Engineering program practice this as group work, workshops and individual assignments always based on the intention to be as close to what students will face after exam in their first employments. Yet there is a major problem with this. Assignments are still not sharp and students know the worst outcome would be to not pass. This paper describes a project assignment connected to an international competition and on a complexity level that needs competences from several different university programs. The project is a competition, which is a successful way to increase focus, commitment and reaching a higher level of result. In this project students have to form their own project organization, plan and distribute work. This is very close to how they are going to act in their future profession and how they have to interact with other professions in the real life situation. Interaction with other programs sometimes occurs but in this project the interaction is on a much higher level because of the complexity and the intensity that is the effect of a competition. Being a part of a bigger project organization gives experiences in collaborating as handling personal problems and people acting unexpected with other competences. Successful competitions results create attention good for students, teachers and the university.

Keywords: Multidisciplinary, applied knowledge, sustainable development, student managed projects, competition

1 INTRODUCTION

The Master program in "Industrial Design Engineering" (TD) at the department of Economy, Technology and Social studies (ETS) at Lulea University of Technology (LTU) has two directions, Product Design and Production Design. The base for the program is classical engineering and Industrial Design collaborating with human conditions and needs to develop future products and services. The program started in 1983 and has been a successful program according to popularity. Lots of students have applied for the program recruited nationwide. There have also been more than 50 percent female students studying in the program, which is unusual when compared to many other engineering programs. From the beginning working in smaller and larger groups with assignments and bigger or smaller projects has been typical for the program TD. These group assignments are designed to be as close as possible to the reality students must handle in their future professional roles and are sometimes formed by the teachers and sometimes by the students depending on the character of the projects. If we look at the program as a whole, group work assignments are set up with an increasing and progressive degree of difficulty. Freshmen have more supervision from the teaching staff and senior students have less. These assignments are open ended at the later part of the program. Teachers are standing in the background, prepared to help if problems show up that students can't solve on their own. This type of setup has been successful during the years and has many good outcomes. E.g. that students graduating from TD have a good experience of interacting with others.

2 THE PROBLEM

From the start of the TD program working in groups has been typical. This is very common in Swedish schools and therefore well known to Swedish students. With this student background it has been a natural way to organize students work from the start of the TD program. This is now a more than 30-year experience. Working in groups is first organized with low complex assignments on a basic level and during the years with a progression of increasing complexity on the more advanced level. Students are forced to collaborate in groups from the very beginning of their studies. Teachers design basic level assignments and the process and results are also mainly training to secure basic skills for the future and more advanced project assignments. These assignments are set up with progression during the program. From having teacher designed projects with rather lot of teacher coaching and teacher design of assignments on basic level to more of teachers standing in the background on advanced level. Student project group assignments on advanced level are mainly planned structured and performed by the students as cooperation between student groups and Industry in "real life projects". The final course "Advanced Product Design" before the master thesis work is a good example of this [1]. To improve project work in courses participating in competitions is one successful way, which has been done both in this course [2] and also by participating in the nationwide competition "Design Open". The industry expressed their appreciation of how well prepared TD students are for working in teams in the industry and appointed TD the award from the Swedish Technological Companies "Sweden's Best Technical Education" in 2005. However, there is still one problem. Even though project courses are well appreciated and having well course evaluations and also have received great appreciation from the industry teachers was aware of shortcomings. Project groups could be more multidisciplinary. In the industry multifunctional groups are how project groups are formed. The product development process in industry is today performed by groups of professionals and not by a single person because an important effect from cross-functional teams is a greater creative outcome [3]. Working in cross-functional teams has since the 50´s become a common way to organize product development. This is the reality our graduated students will face when being employed. Companies like Volvo, BMW, ABB, or consultant companies connected to big companies like this employ many of the students from the TD program. Even though Students from TD have practiced and have good experience of handling work in groups there is a disadvantage. Groups are almost always being formed only by students from the same program, which makes the cross-functional team practice a bit weak. In the TD program multifunctional project groups were formed with students coming from different years of study, having both male and female students and sometimes having some students from related program directions. Compared to reality in the industry this could be improved to cover up the lack of multidisciplinary in the education.

3 APPROACHES

The problem of homogenous student groups is not unique for LTU and the program Industrial Design Engineering. Looking at product design and innovation, attempts to overcome this issue have been made at many other locations in order to prepare the students for a future reality where they cooperate with other competences in their professional role.

At Delft University of Technology, The Netherlands, collaboration is expressed as a key ambition. They state that they want to be a place where students think in interdisciplinary and multidisciplinary terms and where science, design and engineering are the primary driving forces behind teaching and research [4], hence, they also have identified the interdisciplinary collaboration as a key factor to successful innovation.

The same thoughts and values can be identified at Aalto Design Factory in Helsinki, Finland [5]. Three separate universities (Helsinki School of Economics, Helsinki University of Technology and the University of Art and Design Helsinki) merged into one in 2008 and their mission as they describe it is:

"Aalto University works towards a better world through top-quality research, interdisciplinary collaboration, pioneering education, surpassing traditional boundaries, and enabling renewal. The national mission of the University is to support Finland's success and contribute to Finnish society, its internationalization and competitiveness and to promote the welfare of its people"

Interdisciplinary collaboration is one cornerstone in their mission and students from all three disciplines come together at the Design Factory in real life projects with the industry. They want to create an environment where students, teachers, researchers and industry partners can interact under the same roof. This means that the inter- and cross-disciplinary spirit applies to all partners at the Design Factory. Besides the Design Factory, there are two other "Factories" at the university, the Media Factory and the Service Factory.

Looking at the d.school at Stanford University, USA, [6], there is an outspoken intention to mix competences. Here you take advantage of the diversity and they say that instead of working with different pieces of the same project, they navigate each step of the innovation process together. Students from every school at the university take part in the courses as can be seen in Figure 1.

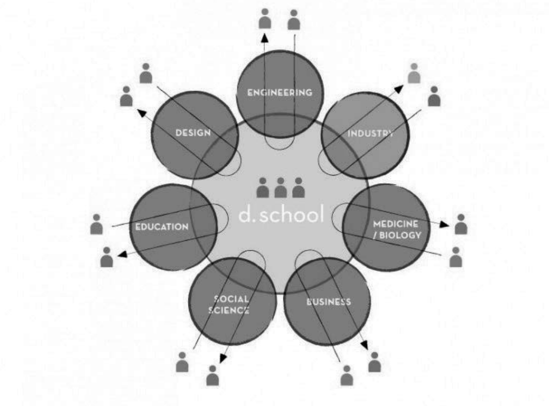

Figure 1. d.school diversity (http://dschool.stanford.edu)

New forms of communication are needed when it comes to interdisciplinary cooperation within teaching and research. Traditionally, universities are organized on disciplinary structures and education is based on traditional disciplines [7]. To achieve an interdisciplinary approach, the learning process is supported by the development of an alternative learning environment where both the students and the teaching staff come from different disciplines [ibid.].

A study made by Kezar, [8], states that institutions are not structured to support collaborative approaches to learning, research and organizational functioning. This resembles the findings from Barth [9] where the creativity and innovation in several major companies, such as IBM, Boeing, Xerox, etc., were studied. The result was that the rigid, bureaucratic structure in these companies did not support creativity and innovation and therefore many companies created stand alone “venture units”, free from the daily business, where this could take place.

4 OUR APPROACH

One conclusion from the survey presented above is that neither the organization of the traditional institutions nor the layout of the applied education supports interdisciplinary collaboration between students or faculty. At the LTU this has also been experienced and one approach to overcome this was made in 2008 when faculty from mechanical engineering, industrial design, business administration and computer science got together to discuss possible cooperation. One critical success factor here was that all members of this faculty group knew each other very well and started the discussions in a very informal way. As the discussions got more serious, the cooperation got more formalized and more tangible suggestions for cooperation were created. The main issue, that followed the discussions from the start, was to create something useful for the students. All participating divisions have similar final year project courses, cap stone courses, where the students are supposed to apply knowledge and skill acquired during their education but in every case the course is carried out with students from the same educational program, e.g. Computer Science. This has some advantages, such as making scheduling easier and the students being more familiar with each other, but also some disadvantages such as difficulty in finding suitable project assignments and the main issue covered in this paper, the students are not getting the needed experience in collaborating with people from other areas of expertise.

The initial discussions originated from an invitation to the LTU from Shell to visit the Shell Eco Marathon [10] as guests with the intention to investigate our interest in participating in that competition. Briefly, one can say that Shell Eco Marathon is a competition where the goal is to create the most fuel-efficient vehicle possible, given certain conditions. The first reaction was that this could really be a project where students from many different divisions could participate and work together in a development team. The fact that it was a high profile international competition only added flavour to the dish. The visit to the competition, taking place at Nogaro Race Circuit in southern France, was a very positive experience. More than 300 teams competing in two main classes, “Prototype” and “Urban Concept”, all gathered in the paddock of the racetrack making the event an enormous exhibition in student creativity.

Back at the LTU, a group of faculty staff members from different divisions were formed. The common denominator being that the people in the group had major responsibility for the cap stone course at each division and great commitment to it. To achieve a heterogeneous group, a preliminary composition regarding the number of students from each division was made. The main tasks were outlined and the different responsibility areas and their intersections were identified. To man the project, each staff member requested applications from the students about to take the cap stone course at each division. From these applications a suitable number of students, according to the tasks and responsibilities, were selected; one main project manager from the division of Business Management, five students from Industrial Design Engineering in charge of the overall styling and ergonomics, five students from Mechanical Engineering in charge of engineering design and manufacturing, four students from Computer Science in charge of software programming and electronic components and finally three students from Automotive Engineering in charge of combustion engine tuning and powertrain.

The financial conditions were such that the LTU guaranteed enough financial support to pay the entrance fee for the competition, build a simple car and send two students to the competition. Anything more than that had to be covered by the students finding sponsors.

The organization of the project groups changed during the project depending on which tasks were in focus. Mechanical engineering students were working in styling, industrial design engineering students were working in manufacturing, etc., depending on where labour was needed. Each group had a representative in a management team lead by the main project manager. In the management team the main project questions were addressed and sub tasks formulated for the different project groups. In theory, this was also the forum for planning of the collaboration of the different project groups. In retrospect, this was the thing that was the most difficult to maintain during the project.

During the initial stages it was decided to go for a hybrid engine setup with a small combustion engine powering an electrical generator. The generator was connected to a super capacitor, which in turn powers an electrical hub-mounted engine that drives the vehicle forward. The main vehicle computer monitors the capacitor and when the current drops to a pre-set value, the combustion engine is started automatically. This was a major challenge for the computer science students and it also needed intensive collaboration with the automotive engineering students.

The main styling was decided through a group decision. The industrial design students developed a number of concepts, which the whole group took a vote on. The winning design concept can be seen in Figure 2.

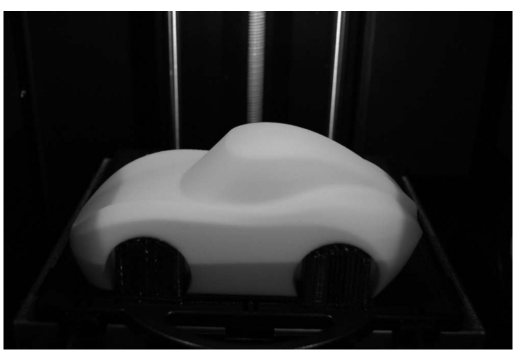

Figure 2. The winning styling concept

During the project, extensive work was made by the students to find sponsors. Anything from nuts and bolts to engines and carbon fibre were acquired as well as scholarships for travel expenses and purely financial support. This made it possible to meet the ambitious goals and expectations set up in the beginning of the project.

Many individual tests and prototype runs were made before it was time to put it all together and time was running out. Since the competition takes place in May and Luleå is covered in snow until April, available time for outdoor test runs was limited. To overcome this, a deal was made with the city to

use the largest indoor sports arena for test runs. This made it possible to fine-tune the design in time for the competition.
The competition itself was a success for the LTU team. As first time contestants, the LTU team won four awards, which can be seen in Figure 3. Best result for an ICE (Internal Combustion Engine) powered vehicle (299 km/l fuel), best result for an alternative fuel (ethanol) powered vehicle, the Climate Change award for producing the lowest amount of CO_2 (6.15 g/km) overall and the Technical Innovation Award for the internally developed exhaust gas recirculation system.

Figure 3. The winning Baldos car

5 OUTCOMES

The main objective of the project was to let the students apply their engineering skills acquired during their education. This was achieved by the highly complex task of building a fully functional vehicle from scratch. Besides that, the most important objective was to allow the students to practice cross-disciplinary collaboration. By combining approaches from already existing capstone courses at the LTU into a larger, cross-disciplinary project it was possible to make the transition from one-competence oriented projects to this multi-competence oriented project more smoothly.
The project's success made it possible to keep it running every year since then. Having successes of different kinds every year, like getting the car approved for road use [11], increases external attention for the project and the university. The students involved feel proud to be a part of this and future students see the LTU as an interesting alternative for their studies.
Working in a high profile project also lead to that the students had to deal with external attention and media [12, 13, 14]. This made them think through how and why they were doing things in the project since it all became public in a totally different way than they were used to due to the interest from newspapers, radio and TV.
Managing and running a project under own responsibility of time, resources and budget inspired the students to invest lots of time and effort in the project. This makes the students more prepared for their future professional role as engineers.
The success also increases staff motivation and commitment to the project and that is a crucial condition for a project this complex to work. High staff commitment also stimulates student commitment [15]. The competition situation also boosts commitment and time invested in the project by the students. It is important, though, to avoid internal competition within the project group since this inhibits performance [ibid.]. To overcome this internal competition, much effort is put into team-building activities to create a strong "we-feeling" within the group. Another effect of the competition approach is that you get immediate and very obvious confirmation whether you succeed or fail.

6 CONCLUSIONS

Participating in competitions is good for increasing student commitment and focus in courses. The competitive situation triggers students to reach for a higher goal. When the result of the competition is winning one or several prizes it is easy to get attention from media. When the competition is international, this attention is even more valuable for marketing the university. Recruitment of students will be more successful and shows the university board that internal support for projects of this kind is well-invested money. Next time a course is set up connected to a competition it will be easier to ask for a reasonable budget for activities like this.

As a synergy effect the teaching staff widens their professional contact net. Contact between teachers in the multidisciplinary groups creates new relations and insights. The teachers become more multidisciplinary as a group and this will establish new educational benefits. To set up a good working organization there must be a selection process to secure having participants with appropriate quality. It is important to find students that are committed to the task and teachers not afraid of involvement and of showing authority if needed. It is a great advantage to have manufacturing resources close at hand at the university and also to have manufacturing companies close to the university. This makes it easier for students to control the manufacturing process while they can produce parts without wasting a lot of time. Having a project with elements of manufacturing can also be a successful way to show the need for investments in manufacturing equipment at the university. Equipment that later on can be useful in other courses, projects or research.

On the negative side, the extent and the complexity of a course like this result in a high work load. This could affect other courses in the program that students have to pass in a negative way.

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