NordDesign 2008
August 21 – 23, 2008
Tallinn, Estonia

Comprehensive design and development projects as master project assignments – Renewing engineering design education

Knut Aasland
Department of engineering design and materials
NTNU
R. Birkelands veg 2B
N-7491 Trondheim
NORWAY
knut.e.aasland@ntnu.no

Abstract
The issue of high burden of master thesis supervision for design students is met with an experimental scheme where a large multi-student project replaces the tradition master project. The project is cross-functional, and will result in a finished product in the form of a vehicle for the Shell Eco-marathon race, built and tested and raced as a part of the project.

Keywords: Design education, master thesis supervision, project group work.

1 Introduction

One of my challenges as a professor of engineering design, is the number of students. The bachelor courses both in fall and spring have up to 180 students, and are heavily focused on project work.We often have one or two assignments per week and 8 to 12 hours per week of project work in our laboratories. This courses are more than sufficient to fill the week.

Our department has a design section, where 3 professors must serve 20-25 master candidates. This comes on top of the bachelor teaching. For each professor, this means some 7-10 students to supervise in large projects both fall and spring. It is a formidable challenge to provide quality supervision under these conditions.

The number of stundents, or the quantity of teaching, clearly reduces the quality of supervisions. Long term, this may lead to reduced application level, which again will lead to reduced quality of the students we admit. The university, however, aims at a position amongst the top technical universities in Europe, and this will, no doubt, require quality improvement also for the master project phase of the study.

Research should be an integral part of our work, but with such an amount of teaching and supervision, it suffers. Publication level is low, which again influences the university's ranking.

The challenge has therefore been: How can we continue to supervise a large number of master students without sacrificing bachelor teaching and while leaving time for research projects?

2 Goal

The goal has been to find a new way to supervise master projects, so that the work load is reduced, while maintaining or improving the student's learning and development compared to the traditional way. It should be "sustainable", so that it can be reused for years to come, and it should create enthusiasm and interest in design among students.

3 Idea generation and background from experience

It is difficult to find theories related to the problem of supervision. We have therefore had to resort to idea generation and evaluation of these generated ideas.

In my university department, we have limited experience with alternative ways of doing master projects. We have, however, followed what Stanford University – and especially their Center for design research – have done [1]. That university is leading in the US in design research and education, and is seen as a place where interesting scientific development is combined with interesting experiments in education. We have followed their work for some years, and has gotten inspiration from this also earlier in our work. The Stanford ideas of methodology in education of design is presented in [2].

There are obviously many ways to achieve a reduction in supervision load for a university teacher. We have discussed these:

1. PhD candidates take over much of the supervision.
2. Candidates are referred to tutoring or answers on the internet.
3. Projects sufficiently connected to industry for industry personnel to take of most of the supervision.
4. A group of students work together so that they can support and educate each other.
5. We tell the students that they are on their own.

The latter is no solution. It is, no doubt, our responsibility to convey expectations, requirements and even methods and techniques, which we want them to use. We think such a strategy would be extremely short-sighted, and would in the long run lead to less interest in design from students, and would also lead to reduced learning and reduced quality of student work.

To leave supervision to PhD candidates is, of course, a good strategy. It does, however, require that we have PhD candidates and that these are suited as supervisors. The same goes fro industry personnel. We have already done this extensively, and our experience is that some of our industry contacts are good supervisors, whereas others are so hung up in day to day problem solving, that they do not understand the need for master candidates to have a scientific approach to their project.

Finding supervision on the internet is not seen as feasible, although some promote this idea intensely. There is no guarantee that anybody on the net will be willing to supervise or even answer questions, and certainly not if it requires work on the part of the supervisor. This presumes that there is a pool of underemployeed scientist in the world, and that those would want to use their time on unpaid supervision of people they do not know. And if, by chance, some student should be able to set up such an arrangement, the issue of quality assurance remains. On the net, people are not always who they pretend to be.

If many students are to be supervised with reduced effort from the teaching staff, I see only one solution which is both realistic and defensible: A group of students working together. The ideas is that they can "lift each other" scientifically, by learning from each other, while also supporting each other in the work. The teacher's role could then be reduced to mostly supervising the processes that take place in the group, to ensure the quality of the work.

4 Suggested scheme

While I have earlier presented a large number of possible master project subjects within my area of expertise for the students, I have now chosen to present only one, and this one would require a team effort to make any sense. I had come across Shell's Eco-marathon competition – an international competition between student teams designing and building cars with the highest possible mileage. To use this for master project, was tempting, because it is about design for environment – a hot issue nowadays – and because it is an international competition.

The only master project for this year, therefore was to design and develop a car for this competition.

This proved to be an excellent choice. Shell is actively seeking to position itself as a future oriented environmental company, and they have a person in Norway dedicated to the Eco-marathon. They wanted very much to have our university enter the competition, and have been very helpful towards the project team. The Shell personnel does, however, not have a technological background.

Another reason the project was a good choice, was that we soon found out we needed additional competence to that held at our department, and which we could expect our students to have. We therefore set up a planning team with personnel from Industrial design, Energy and process technology, Electrical power technology, and Production engineering, in addition to myself and others from my department. All these have picked students to be project team members.

The resulting team consists of 11 students from 5 departments. In addition, a bachelor class in industrial design supports with design ideas and contributions on everything from vehicle interior to aerodynamics.

Of these, 6 are my master candidates, a comparable number to what I have had in preceding years.

The assignment is different from what we have earlier used: There is no detailed assignment for each student, which can be used for individual assessment. On the contrary; the most important success criterion, is that a good and competitive vehicle is ready to start in Nogaro, France, on May 22, 2008. This was absolutely necessary, as we soon discovered there were many necessary tasks in the projects, which did not fall within the scientific specialization of any of the candidates. We feared that each candidate would concentrate on his or her specialization, and foresaw that this would make it impossible to reach the goal of a successful vehicle at the startline. To remedy this, all the teachers came together and agreed

that we would set common grade for the total project, and then an individual one for each student. The final grade would then be a combination of the two.

5 Analysis and evaluation

At the time of writing, the project is not finished. We therefore cannot give any final result. There are, however, some factors of the project which should be discussed:

”Total project”

To develop a car for such a competition, is a costly undertaking. Many components must be purchase. Regulations enforce many restrictions and many requirements, and this leads to extra cost. It means that financing becomes an important issue in the project. The university does not have the required funds. Sponsors must be found. This means intensive and high quality marketing of the project, and it makes it necessary to find solutions that are satisfactory to both sponsors and the team’s ambitions, and that means that compromises have to be made that could otherwise have been avoided. We find that this makes the project more “realistic”, in the sense that it has more in common with projects the candidates will encounter later on in their career than do typical master projects.

Group project

A group project is very different from a single-person project. Quite clearly, a number of effects of the team influences the development of the project: The varied competence of the group members means a much more complete project result; differences of personalities within the group contributes to resolutions of problems which might otherwise stop the project progress; and finally it is important that you have somebody to discuss the project with at any time, and that they are people who, like yourself, is committed to the project.

Group project with external support

This has proved to be more important than anticipated. All the time, there are processes going on between the project team and Shell that I do not have insight in, but which obviously contribute to progress in the project. At the same time, the Shell representatives are professional enough to never forget that it is an educational project, and that they must obey the rules of education, and never expect the students to do work for Shell.

After we got the main sponsor into the project, we have seen him as another serious external supporter of the students’ work. The main sponsor connected the project group with Zero, a foundation for awareness of climate change, and got them to quality check the environmental properties of their solution. Also, the main sponsor has asked for presentations for his personnel, has been a discussion partner regarding choice of propulsion technology etc.

All this has taken place without any burden on the teacher. In fact, I have often been informed after the fact.

International competition

For our project team, competition has been an important element. The importance of doing well in the competition has grown over time. The teacher were initially very realistic, and

meant that we could not expect excellent results in our first year of participation, on the contrary, we felt that if the team managed to go through the race, it was a success. The students have, however, become more and more confident, and now say they aim to not only win their class, but to set a new record (of 850 km on the equivalent of 1 liter of petrol). That means beating nearly a 100 competitor teams, many of whom have years of experience, and many of whom will race cars that have been improved over many years. The ambition has no doubt inspired extra effort on the students' part.

6 Conclusions and further work

This has been a major experiment in how our master projects can be handled with many candidates and limited effort on the supervising teacher's part. In my department we are a small group of 3 teachers who together supervise some 20 to 25 candidates. This is a formidable challenge. In order to ensure quality we have to find new ways to handle this.

Half-way through the first experiment with a large group project with external support, the results look promising. We have seen that the student team support each other, thereby greatly reducing the need for teacher supervision. They find answers internally in the team, and only inform the supervisor afterwards. At the same time, we see that defining the project as a "total project" reduces discussions about formalism. There are no discussions about what falls within and what fall outside of the project; the project's overall goal makes this so evident. This means that discussions can concentrate on more interesting scientific or technical issues. All in all, this is very positive.

We are not yet there. When this project ends in June 2008, we must put it through a thorough evaluation. We will then see if this should continue, and we will see if it should be the only way to do a master project in our department (or at least for our group of 3 teachers). We will also go into improvements and further development of the scheme, both to increase attractiveness and to ensure quality. At the moment we are in discussions with both Stanford and MIT about possibilities for common projects, and we also look into exchange of student groups. Whether or not this will succeed, is too early to tell.

References

[1] Course description of Stanford's ME310 course: http://engineering310.stanford.edu/07-08/index.php/Main/About310

[2] Skogstad, Philipp: "Understanding and learning the innovation approach of Silicone Valley - Findings from Transferring the Stanford University Design Methodology to the University of St. Gallen", report from the MBA-program at Universität St.Gallen, St.Gallen, Switzerland 2006