Abstract

Engineers are basically designers. In many engineering programmes, therefore, some training in design is incorporated. In the undergraduate (BSc) TU-Delft Electrical Engineering curriculum, a design project has run for about ten years. In this project, small student teams (two students) take up the full responsibility of design and realisation of a technical system. The design methodology of the integrated product life cycle of technical systems plays a key role. The project is scheduled as a full time activity during the last quarter of the third year (i.e.: end bachelor phase). A few years ago it was found that an extra didactical dimension could be incorporated, viz. learning to co-operate in an international team. It was supposed, however, that a didactical enrichment could be obtained by introducing remote co-operation. This could be established by letting the students co-operate while staying in their home universities and communicating electronically. In this contribution we report on the process of putting up a co-operation with other universities and the problems that arose. A pilot project was established with the TU-Berlin and the results of this project will be discussed. On the basis of a thorough evaluation of the project a second pilot was initiated, which runs in the second term of the academic year 2002-2003.

Keywords: Project, design, international.

1 Problem analysis

The term 'design' appears to be interpreted in many ways. It may be just associated with the styling of a product, or, at the other end of the spectrum, it may include the entire process from a roughly described problem to a final product. In this proposal we will use the term design in its broadest sense, i.e. it includes a full analysis of the problem underlying the project, the generation of a programme of requirements, the formulation of alternative concept solutions, the selection of the most promising concept, the creation of a product and the final testing and delivery of the product, including all relevant documents. This implies that the students have to develop an open view for the background of a client. Usually, a client expresses his problem in terms of a solution i.e. a product. The designing engineer, however, should be able to reveal the underlying problem in order to be able to generate alternative and, possibly, more adequate solutions. This requires communication skills and the ability to transform the needs of the client into engineering terms such as to develop a technical product that enables the client to solve his problem. This latter issue implies the highly important observation, that technology doesn't solve problems, but that human beings solve problems with the help of technology. As a consequence, engineers should be conscious about the persons that are involved in the final product, in other words: they are responsible for the oral and written instructions for usage, maintenance and disposal or recycling of the product. Presently, engineers do not operate as single problem solvers. They usually operate in teams. More and more these teams are composed of members from different countries and different cultural backgrounds. It is therefore essential that students learn to co-operate in international teams. Design education in international teams has been practised for many years e.g. in Denmark [1]. It was supposed, however, that a didactical enrichment could be obtained by introducing remote co-operation. This could be established by letting the students co-operate while staying in their home universities and communicating electronically.

Finally, projects have to be carried out within a limited period of time. The previously mentioned aspects impose an additional difficulty when trying to maintain a time schedule.

2 Educational objectives

On the basis of the problem analysis discussed above, the following educational objectives for an international co-operative project were formulated:

1. Developing the ability to design a (real working) product within a methodological framework including
   - investigation of needs of a client, based on key questions like who is the client? what is the underlying problem? why is it a problem? etc)
   - specification of requirements for the product to be designed (thinking in terms of functions, rather than solutions
- development of blueprints or conceptual systems, choice of final blueprint on the basis of the previously developed requirements: design
- elaborate blueprint (prototype)
- production incl. putting into use
- use, management, maintenance
- disposal, recycling
2. learning to communicate with
- clients
- potential users
- supporting staff and technicians
- other people having an interest in the product
3. learning to co-operate in an international team, taking into account that team members differ in time schedules, physical locations, cultural backgrounds and prior knowledge and skills
4. learning to manage the time available for the design and creation of a product under the constraints mentioned above.

3 Previous experience

In the BSc-programme Electrical Engineering (3rd year) at the Delft University of Technology, experience has been gained with a project based module, in which students in teams of two are faced with a design task; this module is called the Integrated design project [2]. The design methodology of the integrated product life cycle of technical systems plays a key role [3]. This product life cycle is depicted in Figure 1.

Figure 1: The integral life cycle of technical systems

This life cycle consists of seven phases:

A. Investigation of needs of a client, based on key questions like: who is the client? what is the underlying problem? why is it a problem? etc)
B. specification of requirements for the product to be designed (thinking in terms of functions, rather than solutions
C. development of blueprints or conceptual systems, choice of final blueprint on the basis of the previously developed requirements: design
D. elaborate blueprint (prototype)
E. production incl. putting into use
F. use, management, maintenance
G. disposal, recycling

Within the framework of the student project there are three periods:

I: In an iterative way the first three phases are passed through; this phase is concluded with an intermediate presentation (formative assessment), in which they present their proposed solution to the client. After having obtained the agreement of the client, they proceed to the next period.
II: The proposed system is constructed and the result is tested using the PoR as a verification protocol
III: The last period (not depicted in Figure 1) is spent to finalising: preparing for final presentation, finishing all documents; this period is concluded with a presentation and the assessment.

The character of the project is that of a role-play. The students play the role of an engineering office. The role of the client is played by one of the teaching staff members of the department. Another teaching staff member coaches the team. His role is coaching the students as they pass through the process, rather than giving advice concerning the contents of the project. The students have to acquire technical assistance themselves but the coach might help them to find the right persons.

4 Developing the international co-operative project

We decided that the objective of learning to co-operate in an international context could be met by developing an international variant of the project: the International Design Project.

In order to create a network of possible co-operating institutions the project co-ordinator paid visits to five universities in Europe. From the discussions with the tentative partners the following conclusions were found:

- All visited institutions were positive about the project
- The institutes were less familiar with a design project that is more methodology oriented rather than content oriented, this is discussed in more detail below
- A possible joint project should be carried out in the final stage of the undergraduate programme, i.e. near the end of the third year
- The contents of possible projects should be in the area of (digital) signal processing and/or telecommunication, preferably with an accent on hard ware implementation.
- Possible projects should be carried out by teams consisting of two students from each participating university.
Due to the widely diverse teaching periods, significant flexibility is required as far as the scheduling of the project period is concerned.

Though not immediately visible, the second issue appeared to be a crucial point. In the TU-Delft project, the methodology plays a central role, which means that much attention is paid to a well structured first period. Students indeed follow an iterative process, which, if folded open, can be depicted as in Figure 2:

![Figure 2: Iterative procedure from problem to solution](image)

The starting point is a project defined in terms of a solution ("please, make an system that …"): in Figure 2 indicated with "the best solution". The students have to find the underlying problem and develop alternative solutions. In order to do this, they have to develop a Programme of Requirements (PoR), which is based on the processing of the results of negotiations with the client. The development of alternative solutions and, consequently defining the best solution on the basis of their PoR is a basic educational activity.

The resulting “best solution” may very well differ from the original solution as defined by the client. In the envisaged co-operative project the emphasis was planned to be on the entire process and therefore the project was supposed to be methodology centred. However, usually a project like this can only be introduced in a curriculum as an alternative, if it replaces another module without affecting the educational objectives of that module. This implies, that there is an urge to let the co-operative project be rather domain oriented.

### 5 First pilot project

After the aforementioned discussions, it was decided to run a pilot project with the Department of Electrical Engineering of the TU-Berlin. Though it was decided that the project would run in the second half of the academic year, there was (and still is) a significant asynchrony in the teaching periods of the two institutes. The TU-Berlin so called ‘Sommersemester’ ran from half April till end July. The corresponding period of TU-Delft are the third and fourth term and ran from 29/01/2001 till 29/07/2001 including examination periods. As a compromise the project period was defined as being 5 April till 15 June 2001. Furthermore, it was decided that prior to the actual project, a short introductory course in design methodology should be given to the German students in Berlin. This would made them (a) better prepared to the methods to be put in practice and (b) ‘tune them’ to the knowledge the Dutch students had acquired in their preparatory course ‘Product Life Cycle’. A student manual was produced. The actual contents of the student project were discussed through e-mail and agreed upon before the start of the project. A course website was created in the TU-Delft standard educational learning environment (i.e. BlackBoard). This site was used for both storing course material and communication and archiving for the students involved in the project. The team consisted of two TU-Delft students and two TU-Berlin students. The students met in Berlin for one week (05 – 11 April 2001). The result was a Program of Requirements, a final concept system and a plan for division of tasks per team. On the seventh of June 2001 the students got together in Berlin again and worked for about one week to compose the final system, finish the documents and prepare the final presentation. A thorough discussion between the Berlin staff members involved and the project co-ordinator led to a detailed agreement on the assessment procedure. The final presentation took place on 15 June 2001 and the product was demonstrated. The assessment took place immediately after the presentation and was discussed by the staff members involved. A written statement by the Dutch coach contributed to the assessment. The resulting marks were given using the Dutch marking system (1 – 10). The final result (8) was granted to the Dutch students as such. It was already agreed that, for the TU-Delft students, this marking should be used as a mark for the equivalent Delft course. The final marking was translated into an equivalent German marking that was consequently granted to the German students as a part of their regular curriculum.

An evaluation discussion with the staff involved led to the following conclusions:

- The project can be considered as successful.
- The project was rather staff intensive, but this may improve in future projects.
- The introductory course was useful but very expensive.
- The learning objectives, though to a certain extent different for both institutions (as has been discussed in section 2), were acknowledged and met too a large extent.

On the basis of this pilot, it was decided to run a second pilot project.
6 Second pilot project

In the preparation of the second pilot, the following measures were taken in accordance with the conclusions of the first pilot.

Since the staff involvement didn't increase significantly with larger teams, it was decided to run a project with more students in a team. Due to among other things the interest shown by the students, a team of 10 students was formed: 4 students from TU-Delft and 6 from TU-Berlin. The time schedule is shown in Figure 3.

The introductory course was transformed into a web-based course, which was made available through the TU-Delft Blackboard environment. Both TU-Delft and TU-Berlin students followed the course using this environment.

Exercises were submitted and comments were returned by e-mail.

The key problem (i.e. the differing educational objectives) was solved by splitting up Period I in two parts:

1. Creation of a PoR, developing conceivable solutions, development of a draft ‘best’ concept and draft task allocation (i.e. for the TU-Delft students and the TU-Berlin students)
2. Defining the final concept, final task division and realisation of the product.

Figure 3: Time planning of the second pilot of the IDP

It was decided that the TU-Delft students would be active in the first part of Period I, whereas all students would be active in the rest of the project. Due to some problems with study progress of the TU-Delft students, the transition from phase 1 to phase 2 was somewhat diffuse.

The BlackBoard site was improved such that it allowed for a structured communication and archiving of documents, both within the team and with the teachers involved.

6 Conclusions and discussion

The introduction of international team projects, in particular in the BSc-programmes, is hampered by many factors. We mention the ones that were most significant when introducing the International Design Project.

• Differences in time schedules of the programmes

Projects are most likely to be scheduled at the end of the BSc-programmes. At present, the academic calendars of universities are rather different. As an example, in Figure 4 the calendars of a number of universities are shown. Clearly, much flexibility of both staff and students is required!

Figure 4: Academic periods for different universities

• Differences in educational objectives.

International projects will usually replace at least one of the modules in the curriculum of the participating universities. Obviously, it is desired, that the project lead to more or less the same objectives as the replaced module. This implies, that the technical domain should be defined. In our experience, we found that the area of signal processing is a suitable one. However, we found that less domain specific skills, typically for projects, should be included in the objectives as well. These objectives relate to communication, project management, problem solving etc. The emphasis on these issues may largely differ from one university to another and may be incorporated in other modules, rather than the cooperative project.

• Differences in interpretation of terminology

We found objectives formulated like ‘design’ may be subject to different interpretations. As a consequence, it should be made clear how much emphasis there would be on a methodology and how much on the technical contents. Also, terms like ‘independent working’ have to be made explicit, e.g. in terms of the number of hours of staff support invoked by the students.

It is assumed, that the last two issues will be easier to deal with, if the description of curricula will evolve into output-oriented terms. This is an issue under discussion in many places. As an example we refer to the Output Standards as defined by the British Engineering Professors Council [4].

Acknowledgements

The author gratefully acknowledges the fruitful co-operation with dipl.-ing. Frank Reise and professor Reinhold Orglmeister of the TU-Berlin. Also the 14 students of the TU-Berlin and
the TU-Delft, are acknowledged for their enthusiastic participation in the two pilot projects.

References


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