Integrating research into Project Led Education

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Abstract

Industrial Design Engineering at the University of Twente has organised every quarter of its bachelor around a specific theme with a project as the core element and related courses providing students with the necessary skills and knowledge. While most projects are focussed on designing a consumer product, the focus of the present project lies on the research leading to product design specifications. Students have to design for a specific target group and conduct an extensive needs analysis using several research techniques. The course 'Methods of Research' provides students with the necessary research skills. In this paper, a review is given of the learning goals of the project as well as the organisation of the project that should enable reaching these goals. An exemplary group case illustrates how the cooperative learning process of students is stimulated by the project in practice. Recommendations are made for improvement and implementation into other programmes.

Keywords: project led education, curriculum development, research

1 Introduction: PLE at the faculty of Engineering Technology

At the University of Twente, Project Led Education (PLE) was implemented in 1994 following the Aalborg model (Powell & Weenk, 2003; Aalborg University, 2010). The first programme to adopt PLE as its leading educational philosophy was Mechanical Engineering at the faculty of Engineering Technology (Ponsen & Ruijter, 2002). Seven years later, in 2001, the Industrial Design programme was started at the same faculty. By then, the effects of PLE at Mechanical Engineering were visible. Students were more motivated to learn and the relation of theory with (professional) practice gave students a better understanding of the theory. Because of these positive experiences with PLE at Mechanical Engineering, it was decided to build Industrial Design Engineering on the same educational foundations (Dankers et al, 2013). A second important reason for choosing PLE as the leading educational philosophy is that IDE is a multidisciplinary field of expertise. Project led education, where students have to solve open ended design problems by integrating knowledge and skills from different disciplines enables students to learn the multidisciplinary design approach needed in professional practice.

To realise this, the curriculum was set up in quartiles centred around different themes. Within each theme, a project was defined. In parallel, several courses provide students with the skills and knowledge needed to tackle the problem presented to them. In the project, knowledge and skills from different disciplines are integrated and deepened. Examples of themes that can be found in the programme are: design and development of a smart product, designing a consumer product, systems design, and designing for a specific target group.

The main difference with the implementation at Mechanical Engineering is the variety in group sizes. While at Mechanical Engineering project groups always have a standard group size of eight students, at IDE the choice was made to vary from individual projects to large groups of sixteen students where sub teams have to be made. The objective of this variation is to present students with a wide range of project experiences resembling professional practice.

2 Project 'Designing for specific target groups'

This paper will focus on a project that is aimed at students learning to design for a specific target group. This design project is situated in the second year and third quartile of the bachelor curriculum. In this phase of their education, students have gained some experience in designing products as well as in working in various project teams.

The essence of the project is, that a target group is selected that does not resemble the physical and/or cognitive functioning of the student population. Designing for such a target group forces students to design a product while they cannot use themselves as a point of reference. This lays the demand on students that they thoroughly investigate

the target group and design a product that meets the demands and needs identified for this target group. An evaluation needs to be conducted to verify to what extent these needs are actually met. Where in other projects, the main focus often lies on the synthesis phase, in this project all steps of the design cycle (Analysis – Synthesis – Evaluation) are of equal importance.

2.1. Analysis

The problem analysis phase has a duration of two weeks, starting with an orientation on the project theme. Students gather information about the subject by reading articles, attending guest lectures from experts in the field and make an inventory of possible problems that can be distinguished regarding the project theme. Furthermore, students have to investigate and define the characteristics of the target group that could be relevant to the problem.

A project group investigates the target group and the problem in more depth by means of a literature research. The course 'Research Methods' (see par.3 on project related courses for more information) provides them with the basic knowledge and skills to do this. The information specialist (an employee of the University Library) helps students to formulate useful search terms and find sources for scientific information. In the course, students also learn to perform a critical review of the literature that was found and assess the value of this information for their project design.

The main goal of this analysis is to limit the scope of the problem area. The assignment that is given to the students is very broad and too extensive to solve within the scope of this project. Students need to define a more specific problem and target group. These choices have to be substantiated by facts found in scientific literature. Observations from practice or information from expert interviews can be added to strengthen the arguments.

The problem definition and limitation of scope are reported in an essay together with an idea for a product that addresses the identified problem. To substantiate that no adequate solution for the identified problem is currently available, the essay also contains a market analysis. With this essay the project group should convince the client that their project idea is a suitable and feasible solution for the specific and relevant problem defined. The 'client' (a role played by the tutor and the project coordinator) will give the group a 'Go' or a 'No go' based on this essay. When a 'Go' is received, the group can continue to the next project phase. When receiving a 'No go', the project team has one more chance to come up with stronger arguments or a new product idea.

2.2. Synthesis

After receiving a 'Go' the group has two weeks to work out their product idea into several concept designs. These are presented in a 'design consultation meeting' to an independent expert panel consisting of a project coordinator, a senior designer, an expert in behavioural sciences and a theme related expert (e.g. a physical therapist or a dietician).

During their presentation, the project team indicates which concept has their preference for further development. From the panel, the group receives feedback and critical questions providing them with a more solid basis for their final concept choice.

Within one and a halve week after the design consultation meeting, the project team has to evolve the chosen concept into a detailed design. During a meeting with supporting staff of the material workshop, the group discusses their plans for realising a functional prototype. Parts of the prototype can be produced in the workshop.

The prototype that is realised is not a one-to-one representation of the final design, but should enable the assessment of those functions and characteristics of the design that the project team wants to test with the target group. These functionalities can be present in different, even distinct, elements of the prototype (e.g. foam model, software application, drawing).

Devising a functional prototype lays the demand on the project team to think well in advance about the aspects of the design they wish to evaluate in the next phase of the project and the specific functionalities the prototype requires in order to answer their evaluation questions. The group has two weeks to build their functional prototype in parallel to setting-up the evaluation.

2.3. Evaluation

In the evaluation phase, the project teams set up, execute and analyse a product evaluation of their design. A usability test with real target group members has to be part of this evaluation, but tests on for instance performance or sustainability can also be included.

How to set-up a valid evaluation research is supported through the course 'Research Methods'. Methods for measurements, observation and questioning needed for usability testing are learned and practiced during the ergonomics courses in the first and second year of the bachelor.

The usability test with real target group members is first tried out on fellow students in the course 'Research Methods' in order to verify and enhance the test procedure and prevent ineffective measurements. A paper report is written about the results of this trial describing recommendations for improvement of the real usability test as part of the Research Methods course.
In the project, the design is directly tested on the target group itself. For students, it can be quite a challenge to find their test persons, especially when children are involved. Students have to be resourceful as well as careful in approaching their target group.

In the project report, students reflect on the evaluation outcomes and the conclusions that can be drawn regarding their product design. Students should be able to take the limitations of the test situation into account and interpret their impact on the test results.

2.4. Assessment and closure

For the project assessment, project teams hand in a report justifying the product design as well as the design process. Both are presented and defended during the project assessment before an assessment committee including the tutor and one other assessor.

The final grade is based on three grades for Analysis, Design and Evaluation. All three aspects have an equal weight. The communication and presentation of the design results to the assessors as well as the public is also considered in the assessment. Directly after the assessment, a project market is organized where all project teams can present their design to a broader audience consisting of fellow students, faculty staff and representatives from the professional field or the target group. At this market, students present their project design in an attractive way with a poster, prototype and product presentation drawing. Also, a commercial prospectus has to be made to interest potential clients for the product.

The best designs are acknowledged with respectively an audience award based on a voting amongst the people attending the project market and a jury award based on the voting of a panel of theme related experts. For students, this market is not only a way to present their final product to others, but also an opportunity to see and learn about the designs of their fellow students.

3 Project related courses

In parallel to the project four related courses are taught in this quartile, i.e. Cognitive Ergonomics, Applied Drawing Skills and Research Methods.

3.1 Research Methods

In 'Research Methods', students learn to critically review scientific literature, set up and conduct their own research and document the results. The first activity within this course teaches students to search for scientific information based on relevant search terms and within scientific databases. During this activity students search for scientific information on the problem stated in the project manual and the target group. A 'search report' is made of the literature that was found. The literature found is important input for the essay students have to write, describing the problem definition, the target group description and a justification of the general product idea.

During this course students also practice with reviewing scientific articles and debating on their quality. The articles used for this activity are not related to the project assignment. Students do however use the skills gained here to critically review the value of the literature they find for their own project.

In the third part of the project, students carry out a product evaluation including a 'usability test' with the functional prototype of their design. During 'Research Methods', students work out a set-up for this evaluation research and test their set-up on each other before applying it with real target group members in the project.

3.2 Cognitive ergonomics

Cognitive Ergonomics is the third course in the line of Ergonomics courses within the educational program and deals with limitations in human capacities (e.g. sight, memory) and how this influences product design. This course is more indirectly linked to the project. Students have to show that they are able to attune their design to the physical and cognitive characteristics of the specific target group. Observation techniques learned and practiced in the earlier courses on Ergonomics and Physical Ergonomics are used for making observations during the usability test.

3.3 Applied drawing skills

Applied Drawing Skills is a course in the learning theme of design courses. The course is aimed at teaching students to translate a briefing from a client into a design or drawing. In the project, these skills are used as a tool to communicate a design idea to the client.

The first moment is during the design consultation meeting, where students communicate their concept ideas to the 'client' for feedback. The second moment is at the end of the project where one of the deliverables is a 'product presentation drawing' to present the final product to the client and the audience at the market in an appealing way.

4 Case description

In order to illustrate how students cooperate and learn in this design project, an exemplary group case is described here. This is not a best practice example, but a description of an average group going through the project phases.

The kitchen buddy

Group A consists of six students (3 male / 3 female) in the second year of their Bachelor programme. Together they participate in the project and the course Research Methods. Group selection wasn't done by the students themselves, but by the project coordinator.

The problem presented in the project description is that lifestyle illnesses are an increasing problem worldwide. In the Netherlands as well, more and more people are overweight, including children. Causes are unhealthy or excessive eating and lack of exercise.
The project assignment for this year is to design a product raising consciousness or stimulate children (in the age of 0 - 16 years) to adapt a healthy lifestyle. The product design can be aimed at nutrition, exercise or both. The design should be consistent with the demands following from the behaviour and capacities of the specific target group 'children'.

Group A decides to focus on nutrition by designing a product that engages the child in cooking healthy meals together with its parents. The selected target group they define are children in the age of 6 to 9 years.

In the first part of the project, students start off with a literature search on eating and exercise behaviour of children, obesity, child development and other search terms. To find useful results, students use the skills and knowledge gained in the first part of the 'Research Methods' course on literature search. Their 'search report' will be assessed within the Research Methods course but the literature found provides a starting point for their problem analysis within the project as well.

Based on the literature found, project A writes an essay marking their problem area. In their essay, the target group is limited to the age of 6 – 9 because this is a phase in which children become more conscious learners and are capable to concentrate on a task. From literature they also learn that parents have a large impact on behavioural change in children and that it's important that they set an example. Research shows that parental stimulation is not at a sufficient level yet to contribute to the reduction of the weight problems of children.

For their market research, group A looked at products related to food and toys (internet games, children's cookbooks and smart toys).

The product idea that group A proposes based on their problem analysis, is a 'kitchen buddy', a smart product that interacts with the child about various dishes. While the parent is cooking, the child can play and learn about the food prepared and help by performing simple cooking tasks.

During the design consultation meeting, several variations of this idea are presented to an expert panel.

The concept Group A chooses to continue with is a game console with a built-in kitchen alarm and kitchen scale. A buddy (small figurine / avatar representing a certain kitchen) can be placed onto the base station after which the interaction starts. The child will choose a dish together with its parent. Then the child can alternately play mini-games related to the food being prepared and help the parent in the kitchen. During the game, the child is presented with interesting facts about the food (e.g. where do peanuts grow and why are they healthy?)

For the buddy, several designs where worked out (by making digital sketching), varying from a French cook to a Chinese dragon. In order to find out what type of buddy appeals most to children, evaluative research was conducted with two primary school classes. This evaluation research made clear that the animal figurines where most popular with the target group, so the group continued using the animal versions of the buddy.

The functional prototype (foam model + laptop version of the game) was realised in the workplace and tested with a real family within a family home setting. Both researches were prepared within the Research Methods course. The buddy-evaluation and the practical test were tested within a pilot setting on fellow students to practice observation-making, checking clarity of the questions, etc.

The final design was presented before an assessment committee consisting of two staff members including their tutor. Questions were asked about several aspects of the design, for example:

- Target group: to what extent are the specific characteristics of the target group implemented into the product design?
- Cost price; what part of the kitchen buddy would be most expensive to make?
- Approach for the usability test: what would they do differently next time and why?

To finalize the project, group A presented their Kitchen Buddy at the project market organized for all groups. During this market both an 'audience award' and 'jury award' were handed out to the groups with the most convincing designs and presentations.

5 Evaluation of the project

For evaluation of the project, two sources of information were used. First of all an analysis was made of student evaluation reports regarding the project and related courses. Secondly, interviews were held with the project coordinator and the programme director about the strong points of this project and suggestions for improvement.

5.1 Student evaluation

At IDE, projects are evaluated every year by a student evaluation committee. The project 'Designing for a specific target group' scores well amongst students. The overall appreciation of the project during the last evaluation (2012) was a 7.0 on a scale from one to ten.

Attendance at project lectures was high: 75% of the respondents indicated that they attended 80 – 100 % of the lectures.

Students showed especially high appreciation for the design consultation meeting. They found participation in this meeting very useful (average score 8.1). Students perceive this project as very relevant for the programme (average score 8.4).

As suggestions for improvement, some students indicated that they would like to have more information or instruction on making a prospectus as a deliverable for the project market.

Other students indicated that the duration of the project is too short and more time should be available for the analysis phase.

5.2 Evaluation by the project coordinator and programme director

Strong points identified by the project coordinator are more focused on the learning goals of the project and the relation with other parts of the programme. Two strong points that are mentioned are:

- The relation of this project with research and the Research Methods course in which students are stimulated to look critically at research of others as well as their own work and think about the impact of choices they make in their design and evaluation approach.
- The fact that students do not work linear from problem definition to product design but actually close the cycle of analysis, synthesis and evaluation with each phase being of equal importance.

The problem with the duration of the project as mentioned by the students is known and in the past several variations were tried with for example a longer analysis and shorter synthesis phase, but this only shifted the problem and student complaints to another project phase. The project is bound to a quartile (ten weeks). This is a tight period for a project where students have to work through all project phases paying equal attention to problem definition and evaluation of the product as to their actual product design.

A second possibility for improvement is not so much related to the project itself but to the IDE curriculum. Both the project coordinator as well as the programme director mention this as an important aspect. In the project 'Designing for a specific target group' and the course 'Research Methods', student gain a lot of knowledge and skills on doing research and using these outcomes to justify design choices and strengthen their product design. Transfer to other projects and courses and the final assignment for the Bachelor programme however, could be improved. After completing the project, the scientific attitude largely fades and students easily relapse into the old habit of focusing on the design phase, relying mainly on their creativity and more popular sources of information.

6 Conclusions and recommendations

In this concluding paragraph, some recommendations are made for improvement of the project and the IDE bachelor programme, as well as for other lecturers or educational developers who are interested in implementing a similar project into their programme.

6.1 Renewal of the bachelor programme

At this moment, all faculties within the University of Twente are working on a renewal of the bachelor programmes (University of Twente, 2012). This renewal aims at challenging students to take responsibility for their own learning process and use their study time effectively. Students should gain the basic skills of a researcher, designer and organizer and the ability to develop themselves continuously into new contexts and tasks.

This will be realised by organizing education into fulltime thematic modules in which a project or problem will play a central integrative role. The specific implementation of this model varies between faculties. Some faculties have decided go towards Problem Based Learning, because of a better match with their disciplines. For most faculties however, this means that they are redesigning their curriculum to PLE modules consisting of larger projects and related courses running parallel to the project.

Since PLE is already standard practice at IDE, the bachelor renewal does not have the same impact it has on other programmes. It does however provide an opportunity to take a good and critical look at the existing programme and PLE practice and fine-tune projects and related courses to realise a set of coherent 15ec modules.

6.2 Suggestions for improvement of the project

Looking at the evaluation results and the points stated by the project coordinator and the programme director, several suggestions for improvement of the project can be made.

- Prolong the duration of the project. Ten weeks is a very short period of time when students have to go through all phases of the cycle with equal attention paid to analysis, design and evaluation. No matter how you divide the phases over the project weeks, there is always a point where students feel that they lack time to go in depth. Semester projects as used in the Aalborg PLE model could be a solution. However, this is currently not supported by the structure of the renewed Bachelor programme.
- When the project is bound to the ten week period, a choice could be made to concentrate only on aspects of the project that explicitly belong to the cycle of analysis, design and evaluation and minimize time spent all related aspects like market presentation and prospectus design or leave those to other projects.
- To strengthen the transfer of the scientific approach students learned and practiced in this project, a learning theme around scientific research could be implemented in the new programme, starting in the first year with setting up a simple research for a requirement analysis or prototype testing and concluding in the third year with

a more complex research setup as preparation for the bachelor thesis assignment. At the moment, the bachelor thesis assignment has a very strong focus on design, but could be preceded by a research study resulting in a scientific paper.

6.3 Recommendations to others

To other programmes who would like to implement project led education integrating research, we would like to make the following recommendations:

- Select a project theme that is too extensive to address within the scope of the project. Such theme triggers students to explore the topic in order to define a feasible project, particularly if the topic is not completely familiar to the students.
- Involve the real target group (users) in the project. Work with organisations directly linked to the target group and invite them to give guest lectures about the problems of the target group. If possible let student do interviews and / or experiments with the target group. This will provide them with more insights than only having contact with the client (e.g. company or commercial supplier), thereby enhancing the learning impact of the project.
- Think well about timing of the project and the parallel planned courses. In the project 'designing for a specific target group' knowledge, skills and tools were often introduced in the courses just before they became relevant for the project (just-in-time planning), in other cases the learning effect can be enhanced if project teams struggle and search on their own for a while, before the right tools and theories are provided to them (just-too-late planning).

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