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Designing individual education in a group setting

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Abstract

The structure of the educational program of Industrial Design Engineering at the University of Twente is based on project-led education. Consequently, students are experienced in working as a group in dynamic settings with changing characteristics for every project. The first and second year of the BSc. curriculum provides the students with four projects per year, in which the scheduled educational meetings are the same for all students. However, the broad scope of the industrial design engineering domain should challenge students to participate in the education in such a way that it is most in line with their personal interests. For this reason, students are stimulated to focus on certain aspects of the domain by assuming a specific role in project groups, and by selecting specializations in individual assignments in the third year.

To further increase the room for individualization, a new project has been introduced in the second year of the curriculum. This project allows students to pursue personal interest and expertise, by selecting a subset of the educational elements provided. In doing this, any student is able to focus on only approximately half of the topics offered. While the students are still working in a team setting, the education becomes more individual. Nevertheless, the group is responsible for establishing a setting in which every field of expertise is present. Therefore, selecting the educational elements is not only a personal choice but directly affects the group.

This publication depicts the structure and principles of the project. It also discusses experiences with the new approach, while paying specific attention to the challenging type of assessment of the project.

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Keywords: Design education; collaboration, student driven learning

1. Introduction

The University of Twente (UT) started an educational program on Industrial Design Engineering (IDE) in 2001 [1]. The structure of the program builds on project-led education, mainly to immerse students quicker and more profoundly in the field of expertise they are educated in [2]. Given the impact of educational projects of considerable scope, complexity and scale on the overall program, adequate balancing of the learning aims and implementation of projects and courses is essential [3].

With the university-wide introduction of the 'Twente Educational Model' (TEM) in 2013, the University of Twente aims to closely link the educational approach to the profile of the university as an institution for research and teaching that seeks to combine perspectives from sciences and social sciences. The driver behind TEM is 'Student Driven Learning' (SDL): education that is not fully pre-structured, where the student takes control and ownership of his/her own learning. With this, the student influences multiple aspects of learning, like planning and ways of learning, but also learning goals. This obviously requires significant attention for communication, guidance and feedback between the teaching staff (including researchers) and students. For example, feedback given by professors is no longer limited to the specific field of expertise, but also addresses the learning process itself.

The basic principles of the Twente Educational Model are well-aligned with the project-led education already established in Industrial Design Engineering. In fact, much of the TEM model builds upon the project focus in IDE. As such, the TEM introduction did not cause major shocks, it rather opened opportunities for innovations in the existing educational program. At the same time, discussions started on converting Industrial Design Engineering into an international program

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that employs English rather than Dutch as the default language. Obviously, changing the language of any program requires quite some efforts, however, at the same time it provides an excellent opportunity to revisit educational content and approaches. The structure of the program allows for this, as it is subdivided in a well-defined structure of four modules per year in the three-year Bachelor's program. In anticipation of the start of the English program in September 2016, a number of such modules have been redesigned, where further alignment with the TEM, change of language and refreshing the content have been the main drivers.

This publication focuses on the result of the overhaul of one of the modules. It concerns the final module in the second year of studies, focusing on the development of product-service systems used by consumers.

2. Design Engineering education at the UT

The bachelor program provides students with basic knowledge and skills and a broad view of the field of industrial design engineering. As reflected in the mission and intended learning outcomes of the program, industrial design engineering is a strongly interdisciplinary domain. This forms the basis for the interdisciplinary setup of the Bachelor's program and led to final qualifications for the program. These qualifications have been translated into a set of coherent courses with individual objectives and learning outcomes.

The Bachelor's program is structured around four disciplines: basics, styling, humanities & business and engineering. Knowledge is built up in theory courses; assignments and projects aim at application, deepening and generalization. These projects implicitly and explicitly train professional skills. To ensure that the students can justify and underpin their results and reasoning, the projects also directly contribute to the academic goals of the program. To provide students with the underlying practical skills that allow them to execute projects at the adequate levels of abstraction, creativity and integration, projects usually connect to workshops, laboratory practical's, computer courses and dedicated lectures. Moreover, students are challenged to acquire technical and practical skills in extracurricular activities.

In this educational concept, students start designing from the first day onwards, where the complexity of the project assignments increases during the program. Students experience the need for theory and skills, and learn how to acquire these. Students are introduced to, and guided in, coping with ill-defined problems or situations, to the peculiarities of group interactions and to presenting (intermediary) products to different audiences.

3. Challenges in industrial design engineering education

An important characteristic of a good engineer is the ability to approach problems from different perspectives. By being able to understand, and respond to, the rationale of different disciplines, an engineer can realize robust and widely-accepted solutions. To embed this in an education program requires a curriculum that handles the design engineering expertise from multiple views [4]. The focus should be on understanding the rationale of a specific expertise, not on becoming an expert in each field. A consequence of this broad scope is that every student gains experience in various fields of design engineering. Each individual student may gradually discover where his/her personal interest is, and what the unique 'fingerprint' of that student will be. Consequently, any future industrial design engineer has a different focus and interest. The infinite number of possible combination of expertise creates the need for each student to focus on, and be aware of, his/her personal interest and development. The curriculum must thereby provide the opportunity for personal and tailored education; though it must ensure the final qualification and the quality of the education.

In addition to the broad vision and the personal education, there is a third important characteristic of an engineer, namely the ability to work in a team. This need for collaboration is a direct need related to the broad scope of the design engineering field. The design engineer should be able to select and utilize the expertise and capability of other disciplines during multi-stakeholder development projects. Nonetheless, this offers an educational challenge in combination with personalized and tailored education. This is primarily visible while providing the option to make individual choices on the core activities within a project, in relation to the method of assessing and ensuring quality. In a project-led education landscape each student participates in a, more or less, predefined project. In this group setting, the student can make decisions on what tasks in the project to focus on; however, the offered organized education traditionally is mainly the same for the whole group of students. Therefore, less support from the educational program is offered to facilitate this personal development, let alone rewarding it at the moment of assessment.

In order to improve the collaboration and personalization, the IDE curriculum at the UT stimulates a critical attitude by the students. In groups, the ability to convince one another using clear arguments becomes necessary in order to work conjointly towards a successful group deliverable. The learning process of this can be improved by providing an environment in which each participant can use his own expertise, and where there may also be a difference in expertise between the participants. It goes without saying that peer-learning is an inherent consequence of this approach.

4. Requirement specification of the new project

Throughout the curriculum of the Bachelor's study the four disciplines ensure the coherence and balance between the different educational elements. To face the challenges in chapter 3, while respecting the learning themes, a new project has been developed. The last quartile of the second year is chosen as the best fitting module for the introduction of this project. By then, the students have experienced multiple courses and projects in a variety of different fields of expertise in design engineering, and have encountered multiple forms of collaboration. Individuals can start defining their own preferred or desired discipline, and start focusing on it during the upcoming elements of the curriculum.

The aim of this project is to enhance the possibilities for personalizing the educational elements, while making use of

the dynamic atmosphere of a collaborative group project, all in the broad scope of an industrial design engineer. The project is based on the philosophy of SDL [5, 6]. This implies that the students and teachers have a conjoint responsibility in education and learning. The different subjects (so-called 'design tools') of the module should form an integrated whole, where each element contributes to this, and makes use of the knowledge and skills of other elements. Moreover, the form of education should support a dynamic atmosphere in which student and teacher can adapt to each other. Consequently, formal lectures should be avoided as much as possible, while actual research or design questions should directly be integrated in the lectures. The teacher is not positioned as an expert in each field of industrial design engineering (no 'sage-on-the-stage'), but elaborates his role in the desired synergy of multiple engineers (the 'guide-on-the-side'). Student are allowed (or even challenged) to alter the course and content of meetings, based on the developing needs of the student. This requires a flexible organization in terms of form of education, and content of lectures – not to mention the required mental agility of the teaching staff.

The envisaged project should stimulate the development of all learning themes, with the ability of individual prioritization. In line with the broad scope of the program, the focus will not only be on designing a physical product; it rather is on designing an integrated system of product(s) and service(s).

In order to align the learning aims of this project with the learning aims of the entire curriculum, the following list of requirements is created. After successful completion of the project "Virtual Product Development", a student is able to:

- coordinate the development of a physical product in combination with a digital service;
- formulate an assignment based on predefined parameters and deliverables;
- make a well-founded choice between various design tools;
- transfer knowledge and skills to other group members;
- develop, communicate and organize different configurations of a product in multiple iterations;
- design and create relationships between and combinations of different design tools.

5. Project 'Virtual product development'

The project in the last quartile of the second year (module 8) is based around the theme 'virtual product development'. Students have to work in randomly assigned project groups of 6 students on the task 'to develop a product-service combination' [7]. The aim of this module is about learning to deal with the wide variety of tools available for an engineer. The emphasis is on being able to make an underpinned choice between the various options, and the ability to integrate the selected tool within the project. The focus of the module lies in the design of a product by means of virtual tools. Multiple design variations and iterations play a major role in this process. The project runs for 11 weeks, has a study load of 10 European Credits (EC), and shares the module with the courses 'Dynamics' and 'Introduction to Finite Element Method'. The focus of this paper is the project, the two courses are not elaborated further in this paper.

In general, the Mondays and Fridays are reserved for the components "Dynamics" and "Introduction to Finite Element Method". Tuesdays, Wednesdays, and Thursdays are booked for the project, with the corresponding design tools. The first week of the module is primarily intended to define and present the exact assignment of the project as established by the student teams. Starting from week 2, the tools from the toolbox will be organized. Week 10 and 11 are intended for the project completion and assessment.

The educational model of this module is based on the use of an educational landscape. In this setting, one lecture room is constantly available for this module, and all organized and non-organized education (with the exception of lectures with the need of a laboratory) will be provided in this room.

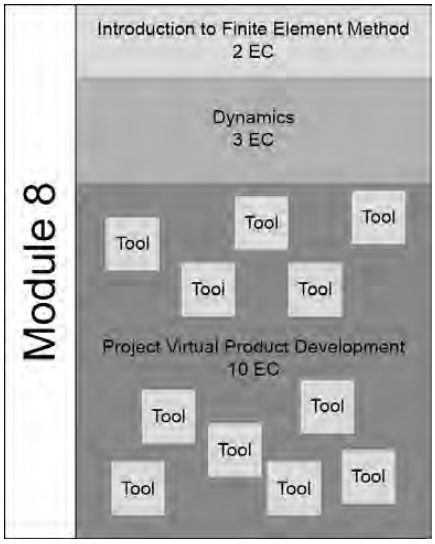

Fig. 1. Overview of module 8

5.1. Formulate own problem definition

In order to stimulate utilizing the broad scope of every industrial design engineer, the first task for the project groups is to define what solution they are going to create in this project, and what problem is solved by that solution. Although there is no exact project description available for this project, a number of conditions and deliverables that have to be complied with in the assignment are presented on the first day:

Develop a product that meets the following requirements:

- *Develop a product-service combination. The physical product should support the intangible service.*
  - *The product will not function without the service*
  - *The service will not function without the product*
- *Used in public spaces*
- *Not personally owned; multiple people can use it*

The project group itself must formulate a precise job description and present it, using one slide, to the project organization and to the other project groups in the first week of the module. The project groups are treated as independent design agencies, and because of the lack of a predefined problem definition, the project team itself has to define a potential market with its according characteristics. The proposed subject should be a reflection of the group members, every participant must be able to maximize not only his/her contribution, but also his/her personal development.

5.2. Selecting a subset of educational elements

Within the project, several design tools are offered in the so called 'Toolbox'. The toolbox is a collection of 11 small courses, each covering a specific subject relevant for the project. The study load of each tool is set on 1 EC, and each tool has its own responsible lecturer. To fit the structure of the toolbox to a potential broad scope of design engineering subjects, the exact number of contact hours and the form of education is left at the lecturer's discretion. The proposed form of education may also change during the project.

Each student must complete six of the tools offered; the student is free in the selection of tools, under the conditions that at least two students and a maximum of four students in each project group select the same tool. The tool selection thus becomes an inherent part of the division of roles in the group. A balance has to be found between the interests of individuals, and the benefits for the group. This quest directly stimulates explicit discussions on the vision of the project, and requires valid argumentation by individuals to defend their preferred portfolio of design tools.

At the third day of the project, the group has to hand in the agreed tool participation to the project organization. A template (in Excel) for this overview is provided, which includes a check if all the preconditions are met.

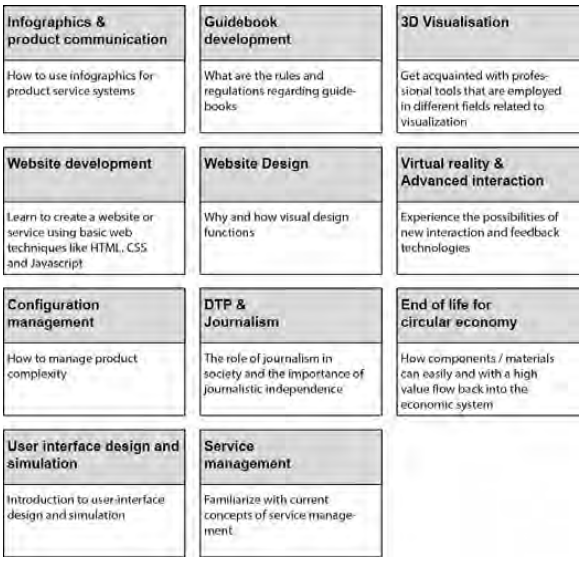

Fig. 2. Overview of tools

5.3. Combine different expertise

All tools aim at implementing the provided knowledge directly in the project, thus having deliverables that are relevant for the desired solution. One of the requirements of the project is that the results of all tools must be visible in the project results, preferably in an integrated matter. Using the right design tool at the right moment, and combining possibilities of design tools is significant. In order to enable a thorough implementation of the results of each tool, the tools have no course specific assignment. The tools are provided as masterclasses to generate knowledge on, gain skills in and discuss content of a specific expertise.

To optimize the use of the design tools, it is essential to transfer knowledge and information between group members following different tools. This peer-learning is essential to achieve a high quality of results in a project group with fragmented expertise. The output from one tool can be the input for another tool. And because no individual student can follow all the available tools, retaining a group overview to visualize the relations will be essential to optimally utilize the tools. This forces the students to explain their gained knowledge from one tool in such a way that another group member can utilize it in the related tool.

5.4. Project execution

The commitment to the project is explicitly made the responsibility of the group, and any use of the expertise available at the university is stimulated. There is no specific tutor pre-assigned to every group, instead, the group can utilize the (e.g. toolbox) experts available throughout the project. During the project, a group can also ask advice regarding the process and progress of the project to one of the advisors. The group must invite the advisor and prepare questions. The advisor will give answers, but will not solve dilemmas nor make design choices for the group. The project organization can, in cooperation with the advisors, also ask the project group for a mid-term meeting with a status update. During the project, this will occur at least once for each project group. This request for a short presentation and meeting will be initiated by the project organization, and will be send not later than three days before the presentation date. The rationale behind this late-announced mid-term meeting is to force the groups to keep all their data and results presentable at all times.

5.5. Convince potential investors

The project groups are seen as independent design agencies, that are not designing for a direct client but rather are engaged in the development of an own concept to attract potential future investors. For this, they will have to convince others to invest at some point in the further development of the concept. Hence, the focus is on developing a complete product service system, where not only the final product is important, but also all the other aspects that influence the decision on the risk analysis of potentials investors.

Each group presents the results of the project in a digital explanation. The explanation contains all information that is

required to explain and underpin the design rational of the final product that has been developed. The final product is the overall concept and possible variants; the product itself, the use context, the market introduction strategy, and the necessary additional steps needed to create the physical product.

The explanation should convince possible investors to invest time, money and/or resources in the further development of the product. This can be compared to the presentation approach of projects on crowdfunding platforms like Kickstarter and Indiegogo. This, for example, gives the students the possibility to use interactive elements and 3D models in their final results, but it also requires to define the future steps and desired investment (in terms of time, money, resourced, etc.). The form of the digital explanation is free to choose (e.g. interactive PDF, website, application), and multiple forms may be combined.

To stimulate the challenge between the different project groups, at the end of the project the students have to present their work for a jury of four potential investors. This is comparable to the BBC-television show "Dragons' Den". These potential investors will select the project group they would preferably invest in, based on the necessary future investment, the potential of the ides, the risks involved, and the expected return on investment.

Only four groups can present their work in a five-minute presentation to the jury. To decide which groups continue to the jury, a qualification round is organized two hours before the jury event. In this qualification every group has to assess all other groups based on six criteria, plus their gut feeling. Every group is allowed only one square meter to present their concept. This presentation should be completely self-explaining, because all groups are – in a strict time schedule – assessing each other's work. This assessment is captured using an in-house developed ranking tool that runs on tablet computers. For each criterion the results for all groups have to be put in a range from worst to best. The outcome of this assessment is computed and compared automatically by the ranking tool. This outcome decides which groups may continue to the jury, it, however, is not communicated to the students instantly.

Every group has to prepare a five-minute presentation for the jury and hand it in before the ranking round. Based on the results of the qualification in the ranking round, the jury event begins by randomly starting one of the four selected presentations. Consequently, every project group has to attend the jury event and will only know if they are allowed to present at the instance their presentation is started by the organization. The jury gives direct feedback and poses questions during a maximum of ten minutes. After the fourth presentations, the dragons withdraw for a moment for consultation and then will announce the winner of the event.

Fig. 3. Dragons' Den during module 8

This "Dragons' Den" event is not part of the formal assessment of the project, and no grade will follow from it. Nevertheless, it is an obvious part of the project.

5.6. Assessment

The assessment of this project is done on an individual and group level. The individual assessment is focused on the individually selected tools, while the group assessment is based on the results from the project. The individual grade makes up for 40% of the final grade, while the group grade makes up for 60% of the final grade. The combination of individual and group assessment enables the rewarding students that excel.

For each tool followed, each student writes a personal essay. This essay describes the application, the use and the integration of the design tool in the project. The viewpoint of the essay is chosen from three directions:

- How did I use/integrate/translate the design tool in the project
- What did I use/integrate/translate of the design tool in the project
- Why did I use/integrate/translate specific parts of the design tool in the project

For each viewpoint, two essays are written; making a total of six essays (for six tools). Which viewpoint is used for which tool is free to choose. In the essays, it is advised to use deliverables of the project as reference or proof. The essays are written in a template, that provides a maximum space in which the essay should be written. It is also allowed to use graphics or images. The completed essays are assessed by the tool lecture(s).

The final results from the project are determined during a project exam. The group presents the results of the project to two examiners using a presentation of maximum 45 minutes, followed by a discussion of two hours maximum. Remarks made during the mid-term meeting(s) can be used as input. In this final presentation, the focus is on the design rationale of the final product, and on the integration and coherence of all 11 tools in the final deliverables.

6. Feedback and evaluation

Project Virtual Product Development is a new project, first run in the academic year 2014-2015. The philosophy of student driven learning has been incorporated where possible. This makes it also important to reflect on the project afterwards with all stakeholders involved to discuss the potential improvements. The IDE program aims to educate academic professionals, and, therefore, the students should also be treated as academic professionals. Consequently, a feedback and evaluation session is planned directly after the closure of the

project. This feedback and evaluation session is organized by the evaluation committee of the student association. To raise motivation among students, and to bring the arguments of the comments to a higher level, it was decided to create a feedback sessions comparable to a multi-stakeholder project meeting. In this evaluation the students are split-up in groups randomly; one group for each educational element of the module. These groups (approximately 6 students) create a list with the positive findings on the educational element, and a list with potential improvements. Using post-it notes on a large piece of paper, these lists are presented to other students, and others are invited to add remarks. Afterwards, the teaching staff joins the group and starts discussing the remarks. On the one hand, this discussion is aimed at ensuring that the feedback is interpreted correctly, on the other hand it focuses on the improvement of the education or on justification of decisions made. Together with the students, a shortlist of the relevant improvements is presented to all other students and lecturers.

The students appreciated the freedom and ability to choose their own field of expertise, although a number of students had difficulties with the very open approach of the project. The lack of predefined roles in the project group led to indistinctness in the groups, which was even more noticeable due to the absence of a dedicated tutor. Even though this might frustrate the results of the project, it does not outweigh the added value of the peer learning.

The inherent relation between tools and project were evaluated as being a refreshing and effective way of putting theory to practice immediately. At the same time students pointed out the risks of possible implementation issues that might endanger the execution of the project. In the evaluation, a number of remarks addressed the assessment by means of the personal essay. Based on these comments, it was concluded that the subdivision in three types of essays might have been a bit too ambitious for second year students.

7. Conclusions

An important characteristic of this new project is that the relationship between different fields of engineering expertise are facilitated throughout all educational elements, but that these relationships are not emphasized nor imposed by the academic staff. The challenge to find these potential relations forces students to critically review their intended activities and planning.

The integration of single-expertise tools in a multi-expertise project enhances the relationship between theoretical knowledge and practical skills. By putting the knowledge into a project immediately, the dependencies and opportunities are directly visible, without the need to make separate assignments for each field of expertise.

Providing the students with the control of defining (parts of) their own assessment criteria by letting them write down their own problem definition, involves them more in their education program. This forces the students to deliberate on every action they are going to undertake during the project.

Organizing a project like this requires flexibility and creativity among all staff members. Unexpected problems will occur, and fast decision making has to result in quick adjustments throughout the duration of the project. This project can only be a success if the preceding projects are well-aligned, while providing complementary contributions to the learning aims of the overall program.

The combination of a student driven learning environment, motivated staff and challenged students, resulted in a new IDE project, in which the students are treated as academic professionals; in line with their education.

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