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DEVELOPMENT OF A TOOL FOR A COURSE IN DESIGN AND TECHNOLOGY FOR THE SECONDARY SCHOOL IN NORWAY

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ABSTRACT
The Norwegian Council of Education has decided to implement a new course in the two last years of the secondary school in Norway. The course is called “Technology and Science”, TAS, and has as main object to give the pupils an understanding of the roles of a designer, an engineer and a scientist, and show how their work is related to development of products, processes and society. The course had a description, but no specific content or learning materials when it started first time autumn 2007.
The course description is very fragmented, and it gives no real support of how to teach and what to teach. Is it possible to use the design process and the design thinking as the leading tread to make TAS become an interesting, challenging course?
We looked at this course as a great opportunity to give our future coming students good knowledge of their future roles as designers, engineers or scientists. This was the motivation for developing a tailored model for TAS which communicates the design process in a simple way and shows how it can be used for any kind of project.
This paper describes the background for the introduction of TAS and the motivation for developing a pedagogical tool based on design thinking and project based learning. The discussion and evaluation is based on results from a case study and response from teachers of the course.

Keywords: Design course, design methodology, design pedagogy

1 INTRODUCTION

The ability to combine practical and theoretical knowledge with creative and innovative thinking is becoming an increasingly important skill to manage in today's social and business life. Based on this, the Norwegian Council of Education has decided to implement a new course in the two last years of the secondary school in Norway. The course is called “Technology and Science”, TAS, and has as main object to give pupils an understanding of the roles of a designer, an engineer and a scientist, and show how their work is related to development of products, processes and society. The course shall contribute to clarify that the interplay between the knowledge areas technology and science can be an arena for creativity and innovation [1].
The pedagogical approach will be of vital importance to whether pupils and teachers will experience the course as a success. The introduction of TAS is positive and will give the pupils early experience with interdisciplinary project work which will be an advantage for their future careers in higher education or working life. The pedagogy must however be customized to fit the course rather than merely adapting the course to

traditional educational techniques.

1.1 Research question

The course description is very fragmented, and it gives no real support of how to teach and what to teach. Is it possible to use the design process and the design thinking as the leading tread and the glue to make TAS become an interesting, challenging course?

2 COURSE DESCRIPTION

The course had a description, but no specific content or learning materials when it first was introduced in the autumn of 2007. It will be a challenge to teach and participate in the course which has no definite curriculum.

2.1 Structure

TAS consists of three subordinate courses: TAS 1, 2 (5 hrs per week) and X (3 hrs per week). TAS 1 and 2 can be chosen independently in respectively the second and third year and qualify as specialist subjects to higher education.
The courses have the following main areas in common: “the young engineer”, “the researcher” and “technology, science and society”. TAS 1 includes “design and product development” in addition. TAS 2 also focuses on the areas of scientific methods and theories and philosophy of science.

2.2 Objectives

Each main area has defined objectives; however the areas supply each other and should be seen as a whole. We want to make a course where a product development project will be the leading thread, and the pupils will be able to investigate the different roles as researcher, designer and engineer through the process. We want a course where the pupils:

- Get use of their existing skills in mathematics, physics, statistics and more
- Feel the joy of creating
- Understand the roles and find their favorite, if any
- Feel the joy of mastering

3 DESIGN PEDAGOGY AND DESIGN BRIEF

According to Moholy-Nagy’s design pedagogy two main ingredients are necessary to set up any educational program: a curriculum and a pedagogical method to transmit its content [2]. The course description does however not include any guidelines to either curriculum or pedagogical method. This aspect was brought up by several teachers with concern and dissatisfaction during a nationally arranged teacher seminar for TAS in 2007 [3].
The quality of TAS will necessarily depend a lot on the teachers own knowledge as well as motivation, time and understanding to teach an untraditional, interdisciplinary course.

3.1 Design thinking and the design process

“[The design process is] the specific series of events, actions or methods by which a procedure or set of procedures are followed, in order to achieve an intended purpose, goal or outcome“, Best (2006) [4].
Using design thinking and the design process as a basis for TAS will be favourable for several reasons:

- Product design is an interdisciplinary field in which technical, aesthetical and user centred solutions are combined in the development from idea to finished product. The designer can be regarded as a connecting link between the engineer, the researcher and the social scientist. Therefore it seems natural to focus on design thinking as a foundation for TAS in order to awaken an interest for the different subject areas.

- The design process deals with the stages from planning and analysis to the development of ideas and concepts to detailing and final presentation. The process which is characterized by diverging and converging phases emphasises that there are many solutions to one problem definition. This means that the pupils' skill to discuss, argue and view things from different perspectives will develop rather than to focus on finding one correct answer. The learning process is more important than the end result.
- Use of the design process will stimulate creative and innovative thinking using the pupils' skill through project work.

3.2 Pedagogy

John Dewey, a philosopher, psychologist and educational reformer, has influenced the world with his thoughts and theories. Dewey's principles have served as a foundation for a number of educational researchers. His visions on education and learning can be summarised as follows:

- The experiences and interests of the pupils must be the starting point for the teaching
- The teachers must involve the pupils when making decisions about contents in the teaching materials and when belonging goals are defined
- The pupils must have the opportunity themselves to shed light on the problems to be addressed based on the idea that learning improves by investigating and acting – learning by doing [5]

William H. Kilpatrick, an American educational philosopher, supported Dewey's principles and believed that learning will benefit if pupils cooperate with each other and if the teacher adopts the tutor role.

3.3 Design brief

Based on the experiences of the authors and the staff at the Department of Product Design Engineering NTNU from design thinking, the design process and design pedagogy, the following design brief was defined:

- The pedagogical approach is project based learning
- The course materials will be presented as a web-based model in order to make it accessible and flexible
- The design process will be the leading thread
- The layout of the web-based model must communicate the design process in a simple way and show how it can be used for any kind of project
- The applied design process consists of six phases and milestones
- The course materials should include themes linked to the phases, examples, showcases and recommended literature
- The model should be user friendly, easy to update and allow teachers to add own course materials and share experiences

3.4 Development of a pedagogical tool based on design thinking

The tool describes the design process through seven main phases: *preparation, analysis,* *idea, concept, detailing and ending*. Each phase is divided in main categories. Within each category various methods and exercises with examples and recommended literature are found.

In this tool the design process is represented by a graphical line. By choosing one of the phases on the line, the next level of the hierarchy becomes visible; the categories. By presenting the process in this manner we are trying to clarify the connection between methodology and its influence in the process.

Figure 1 Screenshot of the tool (the graphical line has been translated to English for this example)

The tool is presented as a web-based model. This model also includes a database where teachers have access to upload projects carried out by the pupils. The idea is that sharing projects will inspire both pupils and teachers.

4 CASE STUDY

During the development of the tool there was a close contact with a national network of secondary schools in order to investigate the needs of both the pupils and teachers and for testing early and improved prototypes. The final proposal for the tool was tested in a case study where three pupils spent three practice days at the Department of Product Design Engineering. Their visit was part of the course objective related to connecting pupils with research institutions. The object for the case study was to find out whether the degree of detailing of the tool was adequate for guiding the pupils through a process and at the same time allowed creative thinking. The testing of the tool was carried out

by observing and asking questions.
The pupils were given a project with the title: *design of a dustbin for waste separation* and were asked to carry it out with the tool as supportive element.

4.1 Results

- The pupils set up a plan for their project by selecting the most relevant methods and exercises from each phase of the tool. The plan included goals and how much time they expected to spend on each phase.
- Initially the pupils found it difficult to use the chosen methods and exercises although the tool had been presented in advance. The pupils seemed to merely focus on finishing an activity instead of really understanding the use of it. This resulted in poor argumentation when the pupils were asked to argue for a certain solution above another. During discussions the pupils realized that choices were made randomly.
- It was suggested that they should examine the tool more closely to see if carrying out some of the presented methods would help them further. The pupils continued with an exercise describing how to make paper mock ups. They discovered that it was easier to discuss their thoughts when they had a physical object to deal with. This was identified as an important learning moment. The following discussions covered a lot of relevant topics.
- During the second practice day it became evident that the pupils had already gained understanding of design thinking. The pupils got inspired by seeing how a student team worked interdisciplinary and followed a typical design process in designing and building an energy-efficient vehicle. During this presentation the pupils saw examples of how a thought-through plan, a list of requirements, sketches, 3D CAD models and physical scale models were a natural part of the design process and helped further development in the process. The pupils worked more independently and spent most of the day making decisions such as size, materials, joining methods, optimal height for cleaning, number of parts and production methods based on sketches, paper mock ups and predefined requirements. The pupils seemed more comfortable and less insecure with the process than the first practice day.
- On the third practice day a 3D model of the final design was made by using a milling machine. The pupils clearly enjoyed spending time in the workshop to create a physical model. While observing the milling they explained how they recognized the use of mathematics as a language.

5 DISCUSSION

The tool is considered useful in TAS based on results from the case study and response from both pupils and teachers. It encourages the pupils to carry out project work in a free manner but at the same time systematically. In traditional courses pupils are followed up closely by their teacher. TAS, however, opens up for a unique opportunity to apply and combine this knowledge in order to solve problems in new ways. It is important that both the pupils and the teacher dare to take full advantage of the freedom which such a fragmented course description actually gives. Experiences from the case study show that pupils benefit from taking the lead in their own projects. By applying design thinking as described in the tool the pupils and the teacher will relate to a common guideline which stimulates a constructive and creative work process.
TAS will demand more than the traditional courses regarding organisation. According

to the course description the pupils are expected to link part of their projects to research institutions and industry. A closer cooperation with the outside world is an important and positive proposal which will make the pupils more aware of how technological and scientific knowledge is used in practice. The schools have to spend extra resources to build a network and maintain contacts so that this will be of interest for all parties.

The tool has received a positive response from both pupils and teachers. It has already been adopted by some schools to be used as support for a semester-long TAS project. However, both active promotion and regular maintenance is needed in order to implement the tool in the course on a national level.

6 CONCLUSION

The design process stimulates creative and innovative thinking. Therefore a tool based on design thinking has been developed for TAS, a new course which lacked both specific content and methodology. This tool is intended to form the basis of what is considered necessary in any educational program according to Moholy-Nagy, namely a curriculum and a pedagogical method to transmit its content. By using the tool pupils and teachers get a description of the design process through seven main phases. Various methods, exercises, examples and recommended literature are connected to each phase and can be combined to carry out any kind of project completely.

In the development of the tool it has been important to keep in mind the great possibilities that lie within a fragmented course description. By deliberately choosing exercises and examples which have a guiding function instead of trying to give answers the pupils are stimulated to work more independently and take the lead in their own projects.

Based on the case study and response from teachers of the course it looks like the tool stimulates the pupils to become independent problem solvers by applying design thinking. The tool inspires the pupils to combine existing skills in interdisciplinary project work to develop a product or system. The model allows teachers to add own course materials. Hopefully this will eventually raise the overall quality of the course by drawing knowledge from experience.

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