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Implementation of workbooks as an active learning tool for Industrial Design Engineering

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***Abstract*—This paper focuses on the workbook approach. It is a tool for active and self-regulated learning, allowing for teachers to guide students in a certain direction and to provide clear goals in otherwise rather open-ended design projects. The learning strategies self-regulated students employ support setting up goals and evaluate their performance, this strategy is guided by the workbook approach. Hence, it supports also previously non-self-regulated learners in devoting to the projects in more informed ways. Industrial design engineering is unique compared to other engineering educations as it combines both artistic and scientific approaches and practices, it combines technical rationality and reflective practice. Typical design projects address the social, economical, cultural, material and technical dimensions of a situation in iterative design thinking cycles of gaining empathy for user needs, visualizing and materializing ideas and concepts and testing with users to inform the process. The workbook approach is a tool to guide such open-ended projects through cycles of reflection in- and on-actions. This informs learning and understanding during the process, rather than afterwards when final results is done. The workbook approach is currently implemented in five compulsory and several elective courses at Industrial Design Engineering (IDE) at Luleå University of Technology (LTU). The results so far are indications of better self-regulation in subsequent courses and students' understandings of the end-result not being the project result, but for them to be the next generation of independent design engineers. As of yet, this is a work-in-progress and more studies are needed to provide evidence of concept such as more active and/or self-regulated learners. The workbook approach however seems to contribute in students being more independent as it guides them through the project process. In conclusion, based on our preliminary findings, we consider that the workbook approach shows indications of being a tool to support active and self-regulated learning in open-ended design projects.**

***Index Terms*—workbooks, active learning, self-regulated learning, industrial design engineering, design thinking**

I. INTRODUCTION

THE focus of this paper is the Workbook approach, an active learning tool that has been implemented at Industrial Design Engineering at LTU Sweden. Drawing on the theoretical background of self-regulated and active learning, through design thinking, this work-in-progress paper describes the rationale behind the workbook approach, aiming to initiate a discussion of how we as educators can contribute to active, self-regulated learners.

Design education has historically been conducted in the form of master-apprenticeship, and more recently as studio-based, i.e. students spending a lot of time in the design studio, where the teacher also devotes a lot of time providing feedback [1]. Critical learning situations in this view often occurs in the studio, compared to the more formal learning sitautions during presentations [1]. The studio may seem as an ideal learning experience for the student, however, the increasing need for efficient use of teacher resources imply a need for new approaches.

In a strive for keeping the formative feedback, merged with an IDE competence profile [2], we have explored and implemented the workbook approach at IDE. In short, this approach directs the students towards writing and reflecting on their own process, methods used, and learning experience gained in the project they currently employ. The rationale is a strive for succeeding active and self-regulated students, who know the learning objectives and expected outcomes of both the projects, separate courses, and the programme as a whole. This has now been a work-in-progress for some five years and it is due time to review the outcome of implementing the approach.

II. ACTIVE AND SELF-REGULATED LEARNING

There are numerous approaches to active learning, with the only thing in common that they all mean that students do something [3]. Most experienced teachers certainly agree that it is rarely enough for students to do something for a good learning experience, i.e. active learning requires a certain direction and clear goals to actually contribute to learning. It is also essential for students to think about what they did and what they learned from doing the learning activity [3].

Self-regulated learning is described as students taking own responsibility and control of their own skills and knowledge acquisition [4]. Benjamin Franklin for example formulated his own learning objectives and on a daily basis wrote of his actions to reach them [4]. Franklin allegedly said that this contributed to arranging his thoughts better. Within higher education, most teachers would probably agree on a general goal being to produce independent learners [5]. The learning strategies that independent learners employ support them in setting up goals and continuously evaluate their own performances, which provides them with better opportunities to steer their own progress in relation to students who don't employ such strategies [4].

III. TEACHING AND LEARNING INDUSTRIAL DESIGN ENGINEERING

Industrial Design Engineering can be seen as unique compared to other engineering educations, as it involves open-ended context-based projects addressing the social, economical, cultural, material and technical dimensions of a situation addressed [6], an interdisciplinary social process

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concerning empathy for human needs and experiences [7], iterative cycles of practice through experimentations and reflections [8], developing specialized forms of visual thinking skills [9],and a frequent practice of formative feedback sessions [1].

To teach and learn design is challenging since it involves a merge between artistic and scientific practices [10]. IDE also exists within two paradigms. In short, *technical rationalism* encompasses a view of knowledge that supports a systematic rational practice. For example, this can involve a design practice starting from a given theoretical framework, carrying out a linear process to solve a given problem [11]. This approach can be good enough when it comes to relatively well-arranged problems. When it comes to problems, which have many dependencies, conditions and possible solutions, there is no right approach, there is no process or activity that provide the right solution, since there are too many options [16]. The paradigm of *reflection practice* is described as conscious consideration of the situation at hand [12] [13], employed in and on actions through methods and materials such as e.g. experimentation, sketching and prototyping [14]. The purpose is still to find a solution to a problem, but it includes a break with the given and immediate situation, which opens up possibilities for change and innovation [15].

To learn to deal with the uncertainty in open-ended design projects can be seen as a portal the students walks through and as a consequence substantially change their ways of thinking and acting once through [17]. This does however not mean that the students understand directly, but rather involves an extended process in which students' struggle with their understandings and needs teachers' continuous support and feedback [18].

IV. Workbooks

The workbook approach at IDE is based on theories of active and self-regulated learning, design thinking, learning portfolios and some principles from the CDIO framework [20], and is currently implemented in five compulsory courses, and several elective courses.

The concept of 'workbook' symbolizes the idea that this approach focuses on reflection-on-actions and work-in-progress, rather than end-results [19]. It is described as an approach that includes a learning process in which the students describes their performance, results and reflections on what contributed to both learning and the result [19].

Design communities often use portfolios for presenting samples of work performed [1]. Typically, portfolios reflect a designer's best work and presents the final design, the artifact, and not the scrubby intertwined process, arguments for why specific methods have been developed and the rationale behind the decisions that are underlying the design process. The latter can be framed as the 'design thinking' involved [15] .

The foundation of the workbook approach is the human instinct of reflecting on experiences, what has been framed as 'learning-by-doing' [21]. The workbook guide students to plan and perform their work in such ways that reflection will take place. Reflection provides better control of the actions, both compared with a blind trial-and-error, and to a linear process of predetermined activities that takes place without any thought or consideration.

The IDE workbook is both a tool for feedback and assessment. The students hand-in get formative feedback on their workbook during the project, feed-forward to up-coming design projects, and a summative assessment of work at the end of the course. The workbook itself consists both of written text, i.e. literature reviews and methods employed, as well as sketches and photos illustrating the process and its results, see figure 1. Typically it involves different sections that deals with a) *this is me*, a page that describes the student and her or his experiences and competences in relation to the IDE competence profile [2]. The workbook is usually structured after the choosen design process, e.g. b) *learn*, c) *design*, d) *build*, and e) *test,* which all have their own theoretical, methodological and analysis subsections. The final f) *reflections and learnings* deals with learning outcomes in terms of both lessons learned, experiences and challenges to address in upcoming projects. In this final section, the students are encourages to show and tell of mistakes, for others to learn, e.g. through peer reviews or up-coming course students, and for the students to be better prepared for upcoming projects. The final reflection concerns the progress of the students' own learning and understanding, and provide opportunities for reflection and self-assessment.

One of the teaching strategies behind the workbook approach relates to the critical four levels of reflection; to be able to 1) describe events and actions taken in specific situations, 2) motivate, discuss and identify possible reasons behind certain phenomena, 3) reflection of alternative actions or solutions and their consequences, and 4) reflect on macro-level, i.e. a broader and more advanced perspective dealing with reflecting on relevance and effects in relation to sustainability, users, user groups, or society at large [22]. The ability to undertake critical reflection relates to the SOLO taxonomys extended abstract, i.e. the student should demonstrate deep understanding of aspects in an integrated whole [23]. This implicates students being able to understand concepts and principles and how they can be used in other contexts than the current project [24]. In turn, this means that a higher level of learning is reached [25].

Figure 1. Example of evidence of learning in workbook, by Sara Kafi TD HT18.

V. Discussion

This paper concerns the workbook approach and how it benefits students' active and self-regulated learning. Since this is a work-in-progress, there are as of yet no results besides our own reflections on improvements of learning results in courses and master thesis projects. Our own evaluation is that the workbook approach have benefits on students being more active and self-regulated, e.g. they better understand the learning objectives, they provide evidence of learning, they don't have to wait for the teacher directing the process, i.e. they know what to do. Future studies are however needed to provide more concrete proof of concept and to perhaps adjust the workbook approach. In conclusion,

based on our preliminary findings, we consider that the workbook approach shows indications of being a tool to support active and self-regulated learning in open-ended design projects.

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