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LEARNING LOGS IN PRODUCT DEVELOPMENT EDUCATION

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ABSTRACT
In this paper, we analyse engineering students' learning logs on a basic course on Product design and development (4 credit points) for second year students. Our purpose is to improve the engineering education by focusing on the learning logs. We want to explore the possibilities of using a reflective assessment tool like a learning log in our courses. For the research strategy, we chose educational design research. Our research focuses on how we can benefit from learning logs in product development education. The learning logs with only a few log entries were lists of activities performed during the course. The most comprehensive learning logs with dozens of log entries demonstrated abilities of a reflective practitioner and knowledge of a variety of tools, and they provided proof of the creation of a design toolbox for future use. The reports discussed the knowledge of key concepts in product design and development and procedural issues. The separation of divergent and convergent problem solving phases and understanding the concepting process was well demonstrated. The learning logs also revealed metacognitive aspects, such as an awareness of personal product design and development skills and potential mental blocks in creativity. The learning logs are useful for the teacher, as the teacher receives feedback on the course, the tasks, instructions etc. The learning logs also reveal what the students thinks and why. This enables the teacher to evaluate the students' skill levels and to plan the scaffolding activities to be used with the groups.

Keywords: Learning log, metacognitive knowledge, sustainable assessment, feedback.

1 INTRODUCTION

In this paper, we analyse engineering students' learning logs for a basic course on Product design and development (4 credit points) for second year students. It is a part of the Tampere University of Technology curriculum on Integrated Product and Production development. Learning logs presented by Barclay[1] can be used as an assessment tool for students' learning experiences. Our research focuses on how we can benefit from learning logs in product development education.

Experiential learning (Kolb) [2] and problem-based learning (Savery et al., Hmelo-Silver et al.) [3], [4] have been used in higher education for a long time. We have been reporting experiences with this approach since 1996 [5], [6], [7]. Earlier, we have not emphasised the meaning of reflection. Our purpose is to improve the engineering education by focusing on this area. We want to explore the possibilities of a reflective assessment tool like learning log in our courses. For the research strategy, we chose educational design research introduced by McKenney et al. [8].

The model for learning logs was adapted from another educational developing research project that was organised in teacher education by Rättyä in 2015 [9]. It included a course on how to teach multiliteracy with picture books. The goal was to develop new teaching methods and instruction strategies for a new course in teacher student curriculum at the University of Eastern Finland. The voluntary course (3 or 5 credit points) consisted of lectures (5 hours), group exercises (10 hours) and independent work with fictional and theoretical texts, and the creation of an E-picture book. In the pilot of the learning log model, the theoretical background consisted of cognitive constructive learning [10], aligned teaching [11], reflective practises and meaningful learning [12].

The research questions were 1) how do learning logs function as a tool for the assessment of students' knowledge change and 2) how do learning logs function as a teacher's tool for developing learning situations. The first findings from 16 learning logs revealed that the learning log format guides students to reflect on actual learning situations (what happened during the lecture and what kind of actions were included in exercises). Students also expressed the idea of a meaningful learning process and meaningful evaluation and assessment. The criteria-based self-assessment with a numerical scale guided students towards argumentative self-reflection of learning processes. For teacher learning, logs provided practical feedback and information on meaningful exercises, faulty exercises or instructions, and knowledge of how students reflected on the theoretical texts used during the course. The research from the learning log pilot led us to introduce learning logs in engineering education and to formulate our research. The idea of a cross-disciplinary project (engineering education and teacher education) is grounded in (or explained by) the intent of both disciplines to aim towards practical and theoretical professional knowledge and professionalism. These studies are based on functional knowledge, which calls for tools for functional assessment as suggested by Biggs & Tang [11].

2 COURSE ON PRODUCT DESIGN AND DEVELOPMENT

The context of this research is a course on Product design and development, with 4 credit points. The students are from the fields of materials science, mechanical engineering, automation and manufacturing. The course was executed in autumn 2015 over eight weeks, and it included six learning sessions. Learning sessions of two hours were taught by a single teacher. The course consisted of six student tasks, which were evaluated separately. To prepare the students for collaboration and cross-disciplinary work, all tasks with the exception of the exam were performed in groups of 3–4 persons, and the maximum score was 20. The learning logs were used throughout the course. The tasks were:

1. To create a new product concept (4 points),
2. To create a concept map on the key concepts of product design and development (3 points),
3. To design an A0-size poster with a product concept and two tools used with the case (3 points),
4. To prepare and give a poster presentation in a joint poster session,
5. To create a personal/group toolbox, with 20 tools for conception and creative problem solving (6 points)
6. To deliver a learning log (4 points) or to complete the exam (4 points).

The students were provided with the logbook template shown in table 1. They were encouraged to choose a learning log format with six rows and six columns, one column per week, but some groups chose a different format. The aim is to capture both group-level and individual-level ideas, based on experiences from the course.

Table 1. Learning log template (translated from the Finnish version). The aim is to capture both group-level and individual- level ideas, based on experiences from the course

		week 37	week 38	week 39
Group level reflection	on design process progress			
	on perceived challenges			
	on applying tools			
	on learnings			
Personal reflections	on design process progress			
	on New Product Development skills			

The learning objectives were planned on the basis of the knowledge dimension from Anderson & Krathwohl's taxonomy table [13] with special focus on metacognitive knowledge and assessment [14]. The objectives derived from the overall curriculum of Integrated Product and Production development consisted of the following:

1. Factual knowledge: Knowledge of a variety of creative problem solving tools and the creation of a 'personal design toolbox' for future use.

2. Conceptual knowledge: Knowledge of key concepts in product design and development.
3. Procedural knowledge: Ability to separate divergent and convergent phases, understanding of the concepting process, use of problem solving tools, use of learning log, demonstration of argumentation and presentation skills.
4. Metacognitive knowledge: Awareness of personal product design and development skills, sustainable self-assessment and learning from experiences. This is to address the need for learning in the longer term and to prepare for future learning needs as identified by Boud and Soler [15], [16].

The genre in learning logs differs from that used in learning diaries, which consist of diary-like entries. Learning log entries are more focused on providing answers to pre-defined questions. The assessment criteria for learning logs were described and communicated to the students at the beginning of the course and were visible throughout the course in the Moodle-environment used. The evaluator was to receive the following information from the learning log:

1. How the design process progressed
2. Which challenges the students experience and how they solved them
3. Which decisions and choices the students made and why
4. What the students learned on new product development and their skills

The groups were able to receive bonus points if they demonstrated creativity with the use or visual appearance of the learning log. The learning logs were evaluated against the above-mentioned criteria. The grade for each group is shown in figure 1.

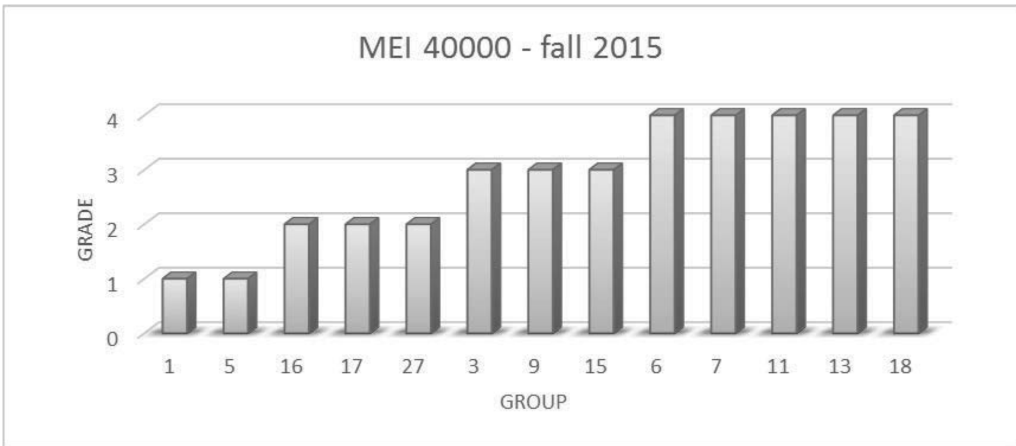

Figure 1. Results from the learning log analysis. Five groups were awarded a grade of 4 (highest), three groups a grade of 3 and two groups a grade of 1 (lowest)

3 RESEARCH STRATEGY AND METHODOLOGY

53 students chose to take the exam, while 39 students chose the learning logs. 13 groups delivered learning logs for analysis. We studied what the students had observed and how those written reflections met the course learning objectives, using the taxonomy table as basis [17]. Then we analysed personal log entries from each student, using data-based content analysis. We elaborated on the research results and discussed the benefits and challenges of the learning logs. The research strategy we used was educational design research, whose main characteristics are that it is pragmatic, grounded, interactive, iterative, integrative and contextual [18]. The goals of the research are pragmatic: they are based on real problems in naturalistic educational settings. Through iterative, integrative and interactive processes, researchers try to find innovative practices to enhance learning. During the research, process interventions are designed by enacting and refining theories.

McKenney et al. [8] have defined a generic model for conducting design research in education. The generic model, presented in figure 1, consists of core processes, which are: 1) Analysis and exploration, 2) Design and construction 3) Evaluation and reflection and 4) Implementation and spread. The core processes result in maturing intervention and theoretical understanding. The iterative research process consists of cycles of analysis, development and theory refinements, and different cycles are reported on [19]. This is illustrated in figure 2. This is our second research cycle. We plan to continue with iterations and carry out this research cycle with engineering students.

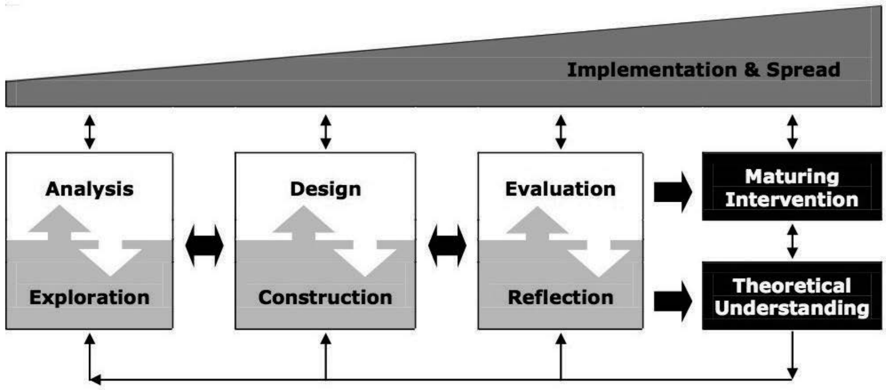

Figure 2. Generic model for conducting design research in education by McKenney & Reeves

4 RESULTS

The length of the learning logs varied. The learning logs awarded a grade of 1 or 2 were quite short; the shortest one was barely one page long, thus having only a few log entries. The learning logs which were awarded higher grades were much more extensive, with the longest 5–6 pages in length. The log entries were more extensive, demonstrating reflectivity and self-awareness. Log entries in the logs awarded the lowest grades consisted of descriptions of activities performed during the course, and they included no reflection at all.

The results presented below are based on the knowledge dimensions in the taxonomy table. The students' responses to factual learning objectives were positive, and the focus on tools and the development of a toolbox was considered a good solution.

A: 'The course broadened my awareness of the vast number of tools available for designing.'

B: 'The course taught us how to use tools in everyday life and in problem solving situations.'

The conceptual learning outcomes were clearly evident in the data. According to feedback from the groups, the dialogue in the groups on difficult concepts was fruitful and also helped to understand how other group members perceive and use those concepts.

C: 'In my opinion, the creation of a concept map was one of the most educational things. While making the map, one had to actually think of the relations between the concepts. We invented examples and found arguments for our own way thinking on why certain concepts are interlinked. The map helped to clarify the overall picture.'

The procedural learning objectives and outcomes were apparent in the learning logs. Many students testified that they are now able to separate the divergent and convergent phases in ideation. They also stated that they are more effective in creative problem solving.

D: 'All in all, thinking about the ideation process and refining it is a skill that I will be using and needing in the future, both in studies and in the work life'

The poster creation process and poster presentations were perceived to be useful. Some students mentioned that they learned presentation skills in poster presentations. Many students reported that it was a useful exercise to see different tools used by other groups and to be able to compare these with one's own work.

E: 'Picking new tools from the poster session for our toolbox was fruitful.'

One student observed that writing facilitated the thinking. Many important design case aspects emerged while writing the case description. Many students observed that they gained metacognitive skills and reported gaining numerous tools for problem solving, as well as the ability to use different tools. Some responses demonstrated self-awareness in reflecting:

F: 'I am old-fashioned as a designer.'

Some challenges and pitfalls in instruction were also reported. Many students reported that the task instructions were unclear and the tasks too ambiguous. Another common theme was the lack of feedback. The students had many tasks, but they only received feedback after each task was completed. The learning logs also indicate a variety of learning outcomes, some of which are not visible in the learning objectives.

5 DISCUSSION

The groups did not receive any guidance or feedback on the learning logs. This can partly explain the low grades in figure 1. We assume that the students are not familiar with this text genre and we need to reserve some time for modelling how to write and use a learning log, instead of just providing the students with a learning log template.

We realised the course and introduced the learning logs in an in-group setting. The group report may have an effect on the use of words and on what is reported. It is important to consider whether to plan a personal learning log or a group version, and this choice needs to be considered against the overall learning objectives. We believe that it is justified to use group learning logs to foster cross-disciplinary collaboration and to simulate real life settings. There is also space reserved for personal reflection to increase self-awareness. In group settings, each student can also compare other students' observations with their own and discuss whether they noticed similar focuses or encountered similar challenges. Another important aspect is to consider how the learning log is formulated and which questions are used to provide guidance and focus for the students' efforts.

The feedback related to explicit task descriptions is familiar to us from other courses. Our intent is to prepare the students to cope in the early phase of product development, when all relevant information not is available and the product concept is not explicit.

The learning logs are useful for the teacher, as the teacher receives feedback on the course, the tasks, instructions etc. If the learning logs are submitted on a weekly basis, the teacher has an opportunity to make changes in the instructions, to emphasise missing aspects or to use different examples. The learning logs also reveal what the students think and why. This enables the teacher to evaluate the students' skill levels and to plan the scaffolding activities to be used with the groups.

When considering the goal of this educational research case, the students reported learning skills as defined learning objectives on the course. If the implementation had been with 35 groups and the teacher had provided feedback on a weekly basis, the workload would have been clearly greater. In our opinion, learning logs do not necessarily reduce the teaching workload, but they do serve as course-learning objectives. It is difficult to evaluate the effect of learning logs on students' learning processes, as no pre- and post-tests were conducted. The importance of the writing process was a surprising result for us. In the learning objectives, we did not consider the role of writing in the product conception process at all. We will consider this in the next iteration. Silius et al. report that in mathematics education, the students perceived the writing about mathematical problem solving to be useful [20].While writing the learning log, the students are practicing meta-skills that are also needed in on-the-job learning. These skills are transferable and prepare students for working life.

The notion of writing facilitating thinking and the emerging aspects of the actual design case are fascinating. It will be interesting to study how different writing exercises could be useful in the engineering design domain.

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