How to benefit from learning logs in engineering education?

T. Juuti[1]
Assistant Professor
MEI Laboratory, Tampere University of Technology
Tampere, Finland
E-mail: tero.juuti@tut.fi

M-J. Kopra
Researcher
MEI Laboratory, Tampere University of Technology
Tampere, Finland
E-mail: mia-johanna.kopra@tut.fi

Rättyä, Kaisu
Adjunct Professor (literary education),
senior lecturer in Finnish language and literature
University of Eastern Finland, Philosophical Faculty, School of Applied Educational Science and Teacher Education
Joensuu, Finland
E-mail: kaisu.rattya@uef.fi

Lehtonen, Timo
University lecturer
MEI Laboratory, Tampere University of Technology
Tampere, Finland
E-mail: timo.lehtonen@tut.fi

Engineering Education Research, Continuing Engineering Education and Lifelong Learning, Curriculum Development

Experiential learning, learning log, self-reflecting, teachers´ learning log, engineering education

INTRODUCTION

Engineering education faces multiple challenges as higher education is in search of excellence with economies of scale and traditional industries are transforming. This is imposed on engineering education both by the ministry of education and by the industry. They strive for students that demonstrate skills of self-motivation, self-

[1] Corresponding Author
T. Juuti
tero.juuti@tut.fi

adjustment and self-reflecting and attitude for continuous learning. As the resources in the higher education will decline the education needs to be more efficient and effective in the near future.

The research on learning logs shows that it facilitates learning, self-reflecting and provides insight for teachers to develop the courses further. The research is mainly carried out in the field of medical studies, teacher education, and non-engineering related studies. Our research focus is on how to benefit from learning logs in engineering education? What information can we get from learning logs for course development?

Our research approach is Educational design research and the research shows that preformatted learning logs provided a thinking tool and focus for the students self-reflection. Students observed that they gained metacognitive skills and demonstrated self-awareness in reflecting. Their observations were valuable input for course development activities.

1 RESEARCH CONTEXT

The context of this research are two product development related courses, Product design and development (PDD) and Integrated product development and production (IPD) in higher education. An overview of the courses is shown in Table 1.

Course	Date	Credits	Duration	Learning sessions	Teachers	Group tasks	Student group size
PDD	Autumn 2015	4 ECTS	8 weeks	6 x 2h	1 person	4/5	3–4 persons
IPD	Spring 2016	5 ECTS	10 weeks	9 x 2h	2 persons	6	7–9 persons

Table 1. Overview of courses

The Product design and development (PDD) course was taught for second year students by one teacher during autumn 2015. The students performed the following tasks in groups of 3–4 persons, and the tasks were evaluated separately. The tasks were: 1. Create a new product concept (4 points), 2. Create a concept map on key concepts of product development (3 points), 3. Design an A0-size poster and present two tools used with the case (3 points), 4. Create a group toolbox with 20 tools for creative problem solving (6 points), 5. Deliver a learning log (4 points) or complete the personal exam (4 points).

The teachers had designed the learning objectives, using the knowledge dimension from Anderson & Krathwohl taxonomy table [13] with special focus on metacognitive knowledge and assessment [14]. The objectives were derived from the overall curriculum of Integrated Product and Production Development. The targets are described in Table 2.

The students had an option to write a learning log together with their group, or take an exam at the end of the course individually. Approximately half of the students chose the learning log. In the Integrated product development and production (IPD) course for 5 ECTS credits for fourth year students, there were two teachers sharing the teaching responsibilities in spring 2016. The course content was significantly changed from the previous year. Students performed all separately evaluated tasks in groups of 7–9 persons. The tasks were: Project breakdown structure, Information flow

modelling, Project schedule and resource plan, Project presentation, Final report and Weekly learning log.

TARGETS				
Course	Factual knowledge	Conceptual knowledge	Procedural knowledge	Metacognitive knowledge
PDD	Available tools Design toolbox for future use	Key concepts in product design and development	Divergent vs. convergent phases Concepting process Learning logs	Personal product design and development skills Self-assessment Learning from experience
IPD	Elements in product development project Elements in team work	Key concepts in product development and production Key challenges in product development	Design reasoning patterns for product development Project plan Development needs in development projects and team work	Personal product development, production and team work skills Self-assessment Learning from experience

Table 2. Learning targets for courses based on *Anderson & Krathwohl taxonomy table [13]*

In both courses, the students were encouraged to use a certain format for learning logs by providing them with a template for the log. The aim is to capture both group level and personal level ideas, based on experiences during the course. The template was a table with six rows and six or nine columns, one column per week (see Figure 1). However, some groups chose a different format and created their own templates but the topics remained the same.

COURSE <name and code>				
Learning log <TEAM>				
Reflection level	Topic	wk1	wk2	wk3
Group	design process progress			
	perceived challenges			
	applying tools/methods in practice			
	what the group has learnt			
Personal	design process progress	Member1: Member2: Member3: Member4: ...		
	development of personal skills	Member1: Member2: Member3: Member4: ...		

Figure 1. Learning log template (translated from the Finnish version).

Learning logs were used to monitor the group task progress and learning, both at a group and individual level. In the PPD course, the learning logs were also graded on a scale of 1 to 4. The evaluation criteria were communicated to the students at the beginning of the course and they were also continuously visible in the Moodle environment for the course. When evaluating the PPD learning logs, the teacher looked for the following information:

1. How did the design process progress?
2. Which challenges did the students experience and how did they solve those?
3. Which decisions and choices did the students make and what were the reasons for making those choices?
4. What did the students learn about new product development and their skills?

2 RESEARCH STRATEGY AND METHODOLOGY

A total of 18 learning log files were analysed. 13 of them were logs (of 41 persons) from the Product design and development (PDD) course, and 4 were logs (of 37 persons) from the Integrated product development and production (IPD) course. One log was written by a teacher of the IPD course. We compared the students' observations and evaluated how their written reflections meet the course learning objectives, using the taxonomy table as a basis [15]. Then, we analysed personal responses for course feedback from each student, using data based content analysis. We also elaborated on the research results and discussed the benefits and challenges regarding the learning logs.

Our research strategy is educational design research. McKenney et al. [8] have defined a generic model for conducting design research in education. The generic model 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 [17]. This is our third research cycle. We plan to continue with iterations and carry out this research further with engineering students.

3 RESULTS

In the following, the results from both courses are presented on the basis of the knowledge dimensions in the taxonomy table. The PDD course students' responses to factual learning objectives were positive, and the focus on tools and the development of a toolbox was experienced as a good solution:

'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.

'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 of 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.

'All in all, thinking about the ideation process and refining it is a skill that one 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 to see different tools used by other groups and to compare these with one's own work was a useful exercise. One student, for example, commented:

'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:

'I am old-fashioned as a designer'.

Some challenges and pitfalls in instruction were also reported. Many students reported that task instructions were unclear and the tasks too ambiguous. Another common theme was the lack of feedback. Students had many tasks, but they only received feedback after each task was completed.

Considering the research question, learning logs with small number of log entries had merely lists of course activities and no evidence of self-reflecting. Students and groups having a lot of log entries demonstrated factual, conceptual, procedural and metacognitive reflection skills. The learning log provides a tool for students to focus, write and reflect on learning activities.

In Integrated product development and production (IPD), we analysed both students and teachers' log entries and those are used to further develop the course. Two groups submitted only one log entry each week, and they reported all group activities in one weekly summary. The other two groups reported all their activities separately, thus resulting in 3–4 entries per week. In the IPD course, there were four learning targets that were often mentioned in the student groups' learning logs. The most popular topics were design reasoning patterns for product development and project planning (i.e. procedural knowledge). They were both mentioned in every third log entry. Conceptual knowledge related to key challenges in product development was also mentioned often. Approximately 20% of the log entries were related to that particular topic. Both factual and metacognitive knowledge were mentioned only in a few log entries.

The IPD teacher's log consisted of 18 entries, 2 per each learning session. The teacher wrote one entry while evaluating the group tasks and log files. Another entry was written during or after the learning sessions. The teacher's log entries were related to resources and time management, types of learning activities, communicating the task assignments, and the preparation needed for learning activities. There were also entries on the terminology used and on presentation material. Some entries were about the work division between teachers, on the IT tools used and on premises.

The teacher's learning log entries were concerned with learning targets, motivation and scaffolding topics. The clarity of learning targets related to the students' motivation level, and interaction level within the student groups was considered. Students' competences (their actual knowledge and skills, in comparison to the competence level the teachers assumed them to have) and the order of the group tasks, i.e. what is the best order for group tasks to enable learning, were also noted in the log entries.

During the course, the teachers analysed the student groups' learning on a weekly basis. They noted that the students met with several challenges when learning the new tools and methods, as well as when trying to understand the practical relevance of the learned topics. The teachers reacted to such learning log entries by modifying the content of the coming learning sessions on a very short notice. Usually, some additional 'real life' examples were presented. Also, common questions and problems related to a previous learning session and group task were addressed prior to when the new learning content was presented.

After the course, the teachers re-analysed the student groups' learning logs and defined how the next IPD course in spring 2017 should be executed. The learning logs indicated a variety of learning outcomes, some of which are not visible in the learning objectives. In addition, some of the learning targets were barely mentioned. Therefore, the learning targets for the next IPD course were re-defined and re-prioritised.

On the basis of the learning log entries, the students seemed to have difficulties with the project delivery scope of group tasks and their attention was directed towards less important topics. In the next IPD course implementation, the scope of the course will be changed to a subcontractor in a project delivery. The student groups complained of unclear task descriptions and they did not understand how their group tasks were evaluated. Therefore, the evaluation criteria for each group task will be communicated to the students as part of the task description. The student groups will also perform self-assessment on their deliverables against the evaluation criteria.

The students' log entries related to the course schedule were similar to the teacher's: there was not enough time reserved for the learning sessions. Therefore, the following IPD course will have 3-hour learning sessions. In addition, the feedback on the previous group tasks will be provided in written format instead of as oral feedback. Oral feedback interrupted the groups' work during the learning sessions.

To help the students to become familiar with the used methods and IT tools, next year there will be a simple 'warm-up exercise' prior to the actual group tasks. This new group task requires one additional learning session, and the total number of learning sessions will be 10. The teachers will also present more 'real life' examples of the topics to highlight the importance of the topics and to motivate the students.

The teachers also noted that some student groups had difficulties in completing their group tasks, because they did not have sufficient knowledge. Usually, the students in such groups were neither attending the learning sessions regularly nor reading the pre-lesson material assigned to them. To enhance the students' knowledge related to IPD topics and to make the group tasks easier to complete, there will be a mandatory pre-course exam for all students. The exam material will cover the most important topics in the IPD course.

Considering the research question, the teachers were able to evaluate how the learning events and material served course learning objectives based on the student and their own log entries. It also serves teacher by providing insight on students thinking and on the effect of different didactic tools on learning.

4 DISCUSSION

The groups did not receive any guidance or feedback on the learning logs in the PDD course. We assume that the students are not familiar with this 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 implemented the PDD and IPD 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. 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' effort.

The feedback related to the need of explicit task descriptions is familiar to us from other courses. The unclarity of tasks is partly intentional, but we do not want to undermine the learning activities. Our intent is to prepare the students to cope during the early phase of product development, where not all of the information 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 thinks and why. This enables the teacher to evaluate the students' skills levels and 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 given feedback on a weekly basis, the work effort 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 PDD course. 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, students perceived the writing about mathematical problem solving to be useful [18].

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.

REFERENCES

[1] J. Barclay, "Assessing the benefits of learning logs," *Educ. + Train.*, vol. 38, no. 2, pp. 30–38, Mar. 1996.

[2] D. A. Kolb, "Experiential learning: Experience as the source of learning and development, David A. Kolb, Prentice-Hall International, Hemel Hempstead, Herts., 1984. No. of pages: xiii + 256," *J. Organ. Behav.*, vol. 8, pp. 359–360, 1984.

[3] J. R. Savery and T. M. Duffy, “Problem based learning: An instructional model and its constructivist framework,” *Educ. Technol.*, vol. 35, no. 5, pp. 31–38, 1995.

[4] C. E. Hmelo-Silver and H. S. Barrows, “Goals and Strategies of a Problem-based Learning Facilitator,” *Interdiscip. J. Probl. Learn.*, vol. 1, no. 1, pp. 21–39, 2006.

[5] T. A. (1) Lehtonen, T. (1) Juuti, K. (2) Rättyä, and M. (1) Vanhatalo, “Retrospective study on teaching engineering design and product development,” *DS 76 Proc. E&PDE 2013, 15th Int. Conf. Eng. Prod. Des. Educ. Dublin, Ireland, 05-06.09.2013*, 2013.

[6] T. Juuti, P. K. Hansen, and T. Lehtonen, “Design Education with Simulation Games,” in DS 46: Proceedings of E&PDE 2008, the 10th International Conference on Engineering and Product Design Education, Barcelona, Spain, 04.-05.09.2008, 2008.

[7] T. Juuti, T. Lehtonen, and K. Rättyä, “Product Development Education - Conceptual Modelling, Knowledge Integration and Metacognition,” in *DS 74 Proceedings of E&PDE 2012*, 2012.

[8] S. E. McKenney and T. C. Reeves, *Conducting educational design research*, 1st ed. London: Routledge, 2012.

[9] K. Rättyä, “Lokikirja ainedidaktisten opintojen arviointimenetelmänä,” in *Ainedidaktinen symposium "Uudistuva ja uusiutuva ainedidaktiikka*, 2016.

[10] E. von Glasersfeld, “Reflection and abstraction,” in *Radical constructivism: A way of knowing and learning*, 1995, pp. 89–112.

[11] J. B. Biggs and C. S. Tang, Teaching for quality learning at university. 2007.

[12] R. E. Mayer, “Rote Versus Meaningful Learning,” in *Theory Into Practice*, vol. 41, no. 4, 2002, pp. 226–232.

[13] D. R. Krathwohl, “A Revision of Bloom ’ s Taxonomy : An Overview,” *Theory Pract.*, vol. 41, no. 4, pp. 212–218, 2002.

[14] P. R. Pintrich, “The Role of Metacognitive Knowledge in Learning, Teaching, and Assessment,” *Theory Pract.*, vol. 41, pp. 219–225, 2002.

[15] P. W. Airasian and H. Miranda, “The Role of Assessment in the Revised Taxonomy,” *Theory Pract.*, vol. 41, no. 4, pp. 249–254, 2002.

[16] J. Van den Akker, K. Gravemeijer, S. McKenney, and N. Nieveen, *Educational Design Research*. Taylor & Francis, 2006.

[17] E. Oh and T. C. Reeves, “The implications of the differences between design research and instructional systems design for educational technology researchers and practitioners,” *EMI. Educ. Media Int.*, vol. 47, no. 4, pp. 263–275, 2010.

[18] K. Silius, S. Pohjolainen, J. Kangas, T. Miilumaki, and J. Joutsenlahti, “What can be done to bridge the competency gap between upper-secondary school and university mathematics?,” in *2011 IEEE Global Engineering Education Conference (EDUCON)*, 2011, pp. 428–436.