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REFLECTIVE DIARIES – A TOOL FOR PROMOTING AND PROBING STUDENT LEARNING

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ABSTRACT

For engineering students to be able to effectively solve problems in their future professions, it is essential that they become self-regulated learners and learn to reflect on their own learning using metacognitive strategies. One way to promote this is to introduce reflective diaries as a writing tool for students, and give them weekly prompts to reflect upon. These prompts should stimulate reflections on learning content and learning behavior, in order to help students in becoming self-regulated learners. In addition, reflective diaries allow for in-depth probing of student learning and can be used as a research method to better understand students' learning processes. In this case study, we describe and evaluate the implementation of reflective diaries in a project-based undergraduate course at Chalmers University of Technology, based on diary entries and individual interviews with the students. We explore the potential of reflective diaries for promoting and probing student learning, as well as offer research-based guidelines for implementing reflective diaries in undergraduate courses.

KEYWORDS

Reflective diaries, inquiry-based learning, self-regulated learning, metacognition, case study, Standards: 7,8, 10, and 11

Introduction

Engineering education has been criticized for neglecting to provide students with opportunities to develop skills that are crucial to practicing engineers and prepare them appropriately for the tasks they will face in their work life (Crawley, Malmqvist, Östlund, Brodeur, & Edström, 2014). One important aspect to achieving this in our knowledge-based society is *lifelong learning*. As problems, contexts, and technologies constantly change and are improved, engineering students need to be able to learn and adapt throughout their whole life (Jonassen, Strobel, & Lee, 2006; Kenny et al., 1998). In order to become lifelong learners, students' ability to engage in *self-regulated learning* is a crucial component (Fabriz, Ewijk, Poarch, & Büttner, 2014). Therefore, learning environments should enable students to own their problems and stimulate them to ask questions like "what do we know?", "how can the problem be approached?", and "where can information be found?". This can be achieved by using *inductive* teaching methods like problem- or project-based learning that place applications and real-life examples first, and

encourage students to engage in self-regulated learning (Prince & Felder, 2006). These methods promote an *active learning* process that encourages the students to take a larger responsibility for their own learning compared to traditional teaching, as well as facilitates the students' acquisition of complex skills, like critical thinking, problem solving, and the desire for lifelong learning (Kuh, 2008). These ideas have also been highlighted within the CDIO approach, as pointed out by Crawley et al. (2014): "a contextual learning approach assists students in learning how to monitor their own learning so that they can become self-regulated learners."

Furthermore, self-regulated learning goes beyond the knowledge and skill dimension of student learning. It requires students to link and integrate *cognitive*, *metacognitive*, and *motivational strategies* in appropriate ways (English & Kitsantas, 2013; Fabriz et al., 2014). Metacognition is the awareness of one's own thinking and learning (Flavell, 1979). It enables students to reflect on their own learning, dissect their own thoughts, argue with themselves possible alternatives, and think about how their experiences will shape their future (Gall, Gall, Jacobsen, & Bullock, 1990). There is mounting evidence that metacognition needs to be taught – it is not something that all students automatically engage in (Wedelin & Adawi, 2014). It has therefore been proposed that active learning methods in engineering education should not only encourage students to reflect on the content, but also encourage them to reflect on their own thinking and learning (Vos & de Graaff, 2004). Tanner (2012) gives a good overview of different teaching and learning activities that promote metacognition, one of them being *reflective diaries* (also referred to as learning diaries, learning journals, or log books in the literature).

Reflective diaries can be used in many different forms depending on the purpose. They can be in the form of a public blog or a handwritten book, they can be written everyday, once a month or whenever something significant happens, and they can be structured in different ways (Moon, 2003). The diaries are a writing tool for students that can help the students' reflection process and promote metacognitive skills by providing them with a medium to write down their thoughts (Walker, 2006). Careful prompt design stimulate students to actively reflect upon the learning content and their own learning behavior, therefore facilitating the use of metacognitive strategies and their integration (Fabriz et al., 2014; Jarvis, 2001). In this way, reflective diaries can *promote* students' learning and support students to engage in self-regulated learning and fully benefit from active learning environments (Boekaerts, 1999). However, little is known about the use of reflective diaries in engineering education and the importance of particular disciplinary contexts (Tanner, 2012).

In addition to *promoting* student learning, reflective diaries can also be used for *probing* student learning, which is an important part in order to understand student learning in more depth and make informed decisions to improve engineering education (Lohmann, 2008). Traditionally, there has been a focus in engineering education research on what students have learned at the end of a course or program with a minor emphasis on the pathways students take to reach this final stage (Schmitz & Wiese, 2006). This is mirrored by the data collection methods commonly used: interviews at the end of the course, surveys, and course evaluations (Koro-Ljungberg & Douglas, 2008). In order to understand the processes in student learning, however, it is crucial to look at the pathways they take during their education, what challenges they experience, what motivates them, and what supports their learning. Reflective diaries enable researchers to collect data more continuously (Rieman, 1993), and open up for the possibility to investigate students' pathways in more detail (Jarvis, 2001). In contrast to observational data, that shows how subjects behave and interact, reflective diaries provide information about the students' thoughts and reflections on situations, in some way similar to interviews, but closer to the moment that they occur in. Schmitz and Wiese (2006) summarized

two important advantages with reflective diaries as a data collection method: “First, they allow to observe learning over time. Second, learning can be investigated with ecological validity because learners complete the diaries in their natural learning environment.”

In this paper, we: 1) explore the potential of reflective diaries for promoting and probing student learning, and 2) offer research-based guidelines for implementing reflective diaries in undergraduate courses. The case study presented here describes and evaluates the use of reflective diaries in an undergraduate course on tissue engineering at Chalmers University of Technology and illustrates our findings by using extracts from the reflective diaries and individual interviews with the students.

Study context and design

The context for this study is an advanced level course (15 ECTS-credits) on tissue engineering that runs over a five-month period at Chalmers University of Technology. The majority of the students take the course in the first year of their master program. The aim of the course is for students to: 1) gain an overview of the tissue engineering field; 2) understand the fundamental science and technology that form the building blocks of the field; and 3) develop research competencies relevant to the field and a research identity.

The dominant pedagogy underpinning the tissue engineering course is *inquiry-based learning* (Lee, 2012; Prince & Felder, 2006), which belongs to the class of inductive teaching methods. To support students during the difficult and complex inquiry process, *expert guidance* is embedded in different ways, for example through lectures, modelling of skills, coaching during activities, and collaborative problem-solving (Laurillard, 2012). The course consists of lectures, article review sessions and a research project. The research project runs over the entire five-month period of the course and all projects are directly coupled to on-going research at the university. The aim of the project is not only to gain a deeper understanding of the outcome but also to experience research as it is conducted to gain an understanding of the scientific process. For a more detailed description of the course see Wallin, Adawi and Gold (2013, 2015).

In 2014, weekly reflective diaries were used with one of the project groups (four students S1-S4) to promote and probe the students’ learning, as well as evaluate the use of reflective diaries themselves. Individual interviews were conducted in the middle and at the end of the course where students were asked to talk about their perceptions and experiences with the reflective diaries. Student participation in writing the diaries was voluntary, but strongly encouraged. The students were carefully briefed at the beginning of the course about the purpose of the reflective diaries and how they could help the students to learn better and support them during their own project work. No points or formal assessment was based on the diaries, and the person reading the diaries was the project tutor, who was not involved in grading the students at the end of the course. All students gave their informed consent that their diaries could be used as research data.

The students wrote weekly reflective diaries around specific prompts. Figure 1 illustrates the design principles used for the prompts. Topics were selected around different phases the students encounter in their projects, general aspects of working with tissue engineering

research, and the students' learning experiences. Through the use of four general categories of questions that encouraged reflections on different levels, specific prompts were designed, exemplified in the figure.

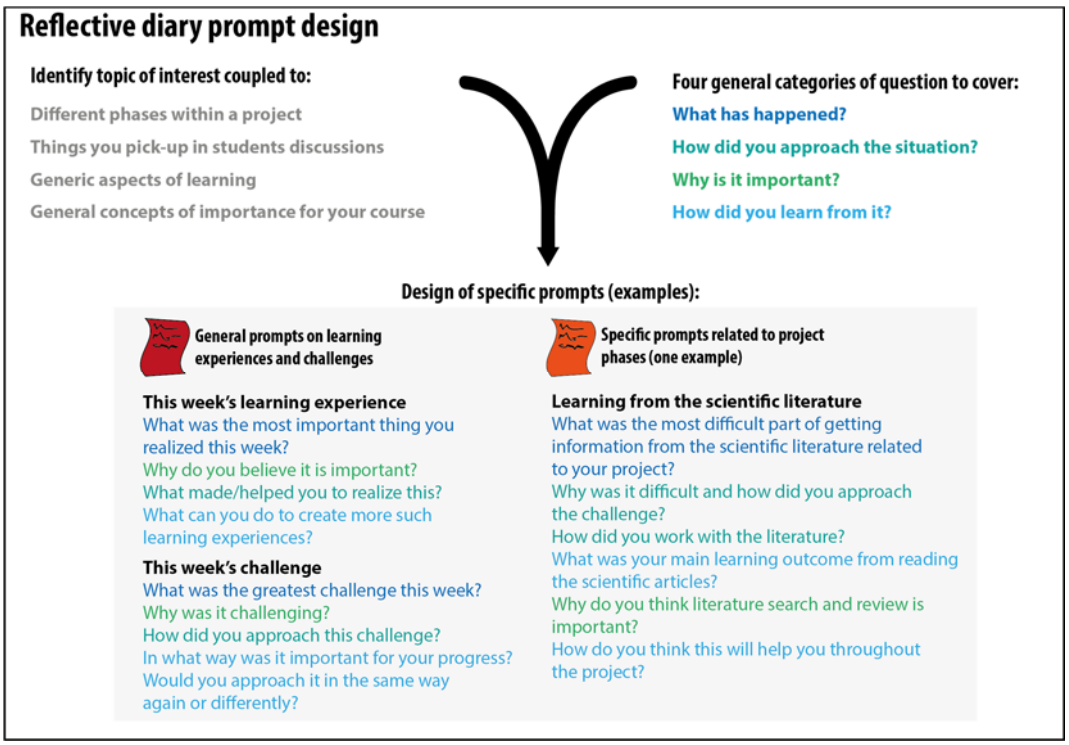

Figure 1. Overview of the general design thoughts behind the reflective diary prompts and examples of specific prompts.

The students received the prompts at the beginning of the week via email and were asked to send their reflections back on Friday afternoon. The prompts alternated between focusing on more general learning experiences in odd weeks and on the different phases of the project in even weeks (Figure 2). By using prompts that were both looking backward and forward, the students needed to reflect upon their planning on upcoming tasks, monitor their actions, and evaluate their performance on completed tasks. On the probing side, this approach allowed us to get process data on the same incident from two different directions or perspectives.

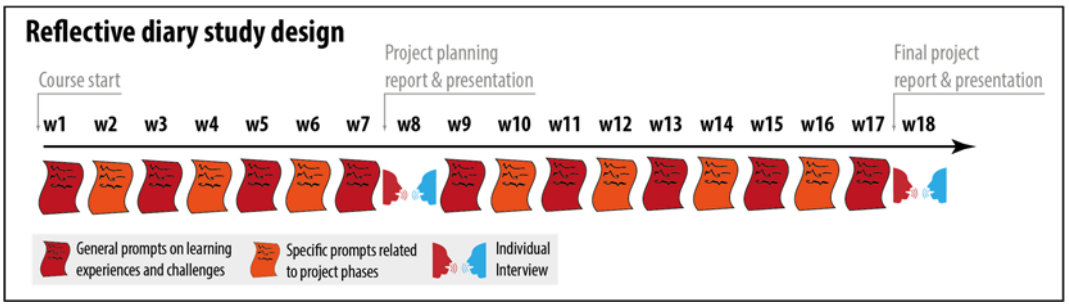

Figure 2. Overall design of the study.

Results

The results for the study presented here are based on two data sources: individual interviews with the students at the middle and end of the course, and the reflective diaries themselves. In order to understand how the students experience writing reflective diaries, we will first take a look at the interview data. In the second part of the results section, we will use excerpts from the reflective diaries to illustrate how reflective diaries help both to promote and probe student learning.

During the interviews, the students were asked to talk about how they experienced writing the reflective diaries. Some students said that it was difficult at the beginning to write the reflective diaries. They did not know what was expected from them and could not fully understand the aim of writing the diaries:

> *I can say at the beginning it was difficult, I did not know what to write, because the questions were so open and I did not know what you did expect us to write (S2).*

One way for the students to avoid this uncertainty and the lack of experience to write reflective diaries is to relate it to tasks that they are more used to and commonly perform at the university, like assignments and writing descriptive text:

> *At the beginning, I thought about it like an assignment and I did not know what to write (S1).*

> *Yes, I agree we are trained to write descriptive text. It is true because we just try to make things very precise and exact all the time (S2).*

This happened despite the fact that the students were carefully introduced to the idea of reflective diaries and their purpose was discussed extensively together with them. The interviews suggest that the problem lies deeper and the students' behaviour cannot be explained by a simple misunderstanding of the task. The students are aware of the task and aims of writing reflective diaries, but they have difficulty doing it:

> *I suppose this is the idea of the reflective diaries that you want to hear what we have in mind, and that there are no rules. But I mean for me it is difficult sometimes to write things like that (S2).*

The students often experience learning at university as a pure cognitive task, where knowledge is transferred from those who know to those who do not yet know, rather than an integrative process where their own experiences and reflections play an important role. They find it difficult to write about their own experiences and feelings, and prefer to write about concrete aspects of their learning, as they are not used to write reflectively:

> *For me, it is difficult to write these kinds of things. For example the questions "what did you feel" and these things, it feels a bit strange to write about them. I prefer to write more specific things. But in the end I think it is good. Maybe it is just that I am not used to do these things (S2).*

It is through continuously writing the reflective diaries that the students that were sceptical at the beginning start to appreciate them more and more. They feel that writing the diaries helps them to sit down and take the time to reflect upon what has happened during the week. By doing so, they experience that the diaries help them to see their own development, learning, and progress:

> *At the beginning, I did not think [the diaries] helped, but later they helped. It is my first time writing something like this. It was good to sit down and think about what I have done during the week… it was really helpful. It really helped me grow and see my own progress (S1).*

> *I think it is good that we are forced to think about things, especially what we learned and also what our working progress has been (S3).*

The diaries are also used as a tool by the students to make their cognitive processes visible to themselves and become aware of their own actions, thoughts, and social interactions within the project group. It helps them to see and reflect upon the challenges that they experience,

the approaches they took to overcome them, and possible improvements in the future:

> *The diaries are a really good way to see for yourself and reflect upon challenges you have had and how you got through them. Seeing things you might want to do better next time. And reflect on yourself as a person in a group and a project. I think it is really good to have (S3).*

This positive attitude towards reflective diaries and ability to use them effectively can be seen in all students at the end. This means that while they have different starting positions due to personal and cultural differences, all students were able to use reflections as a metacognitive strategy to think about their own learning by the end of the course. It is important to keep in mind these differences, as it means that the support students need varies between individuals.

In the second part of the results, we will now take a closer look at the reflective diaries themselves and illustrate with selected excerpts how the diaries are promoting student learning and how they can be used to probe student learning. We will focus on the specific topic of working with the scientific literature, which the students engage in throughout the tissue engineering course. Whereas the interviews gave us an idea of how the students experienced writing the reflective diaries, the challenges they encountered, and development over time, the diary excerpts can illustrate how the prompt design and structure can help the students to reflect upon various aspects.

Figure 3 shows selected excerpts from the reflective diaries in the center column, and the analysis along the promoting dimension on the left and the probing dimension on the right. The diary excerpts are grouped around the four categories that the students were prompted to write about in each topic every week: 1) what has happened, 2) how did I approach the situation, 3) why is it important, and 4) how did I learn from it. For promoting students' learning, these four categories translate into: 1) reflecting on their plans and assessing the challenges, 2) identification of appropriate cognitive strategies, 3) evaluation of their approaches and connections between different parts, and 4) ideas of how what they learned can be used in the future. In addition, the excerpts can be viewed from a different angle with a focus on probing student learning. In that case, the four categories can be seen as 1) to raise the teacher's awareness on the challenges students face, 2) to identify what type of scaffolding and support they need, 3) to understand the students' motivation to work in a certain way, and 4) to evaluate if students are able to see transfer possibilities of what they have learned into other contexts.

Promoting	Reflective Diary quotes	Probing
Planning Writing the reflective diaries helps the students to identify and become aware of the challenges they are facing, as they need to think through them and write about them. They need to analyze their current situation, in order to be able to plan their actions.	**"What has happened?"** *One of the biggest challenges when starting a new project is to classify the information, due to the large amount of information that exists on the network, it is important to classify and select the ones that are relevant to our project.* *The most difficult part is to understand the terminology and become familiar with it.*	**Awareness** The reflective diaries can help teachers to become aware of the challenges that students experience during a project. This information can be helpful to design appropiate scaffolding of the students learning process and provide the right support to them.
Cognitive strategies The next step is for the students to find their own solutions to overcome the challenges they are facing. By writing down their own approaches and strategies and reflecting upon them, the students make them tangible and easier to use. Reflection helps students to opertionalize the information and strategies they recieve in class about the structure of scientific articles and see it in connection to the challenges they face.	**"How did I approach it?"** *However, reading all of the articles by whole text seems impossible. The abstract provides a very good view of the content. Also in the introduction part, a basic knowledge background is provided and there are always a few sentences about what others have done previously in this part, as well as their aims, what they want to improve. It is a good way to learn.*	**Support & Scaffolding** The reflective diaries also help teachers to see how the students overcome the challenges that they experience and the strategies that they apply. The students' strategies can either be coupled to formal course activities or other more informal activities e.g. interactions with other students and web searches. In this way, the diaries help to evaluate the effectivness of certain interventions.
Evaluation Another important aspect is that the students through their reflections start to realize why certain elements are important and how they are connected to each other. In this way, the different tasks also become meanigful. Furthermore, they need to think about their approaches with respect to their goals and evaluate the strategies that they have used.	**"Why is it important?"** *One of the best ways to understand the topics related with the project and be aware of the state of the art is to read articles. In this way we can find the latest research in this area and look at the experiences and mistakes from other researchers to create something new or take a step further in the subject.*	**Motivational factors** Teachers might have a very clear idea why certain aspects and phases of a project are important, however this might not be clear to the students. The factors that motivate students to pursue a task can differe greatly, and it is important for teachers to know what stimulates student learning. Reflective diaries provide the teachers access to these factors.
Future use Finally, the reflective diaries encourage students to reflect upon what they have learned from a task. This includes reflections on how the content of what they have learned can be used within their project or in other contexts, as well as how the used strategies can be used in the future.	**"What did I learn from it?"** *By doing literature research one can get a lot of information and tips from other peoples research to get a more successful project outcome, for example by using existing protocols, not having to reinvent the wheel on every step... I have also learned a lot doing the literature searches, about other peoples experiments, setups and evaluations.*	**Transfer** In addition, it is important to see and evaluate how students use their knowledge and findings within the project. Reflective diaries can help to assess how different project phases are linked together and in what ways students transfer information and knowledge from one to another.

Figure 3. Results based on excerpts from the reflective diaries.

Discussion and Recommendations

Based on the results presented here and the empirical findings by others (e.g. Davis, 2000; Fabriz et al., 2014; Ifenthaler, 2012), reflective diaries can promote student learning and support students to become self-regulated learners, as well as being used to probe student learning. However, from our data it becomes clear that students need training and support to

develop metacognitive and reflective strategies. We want therefore to highlight two aspects that are important to consider when using reflective diaries for promoting student learning: the design of diary prompts and the process of introducing reflective diaries.

On a more concrete design level, the use of multiple types of question in the diary prompts can stimulate students to reflect at different levels and around different topics. It is through careful prompt design, which focuses on both learning content and learning behavior, that reflections can help students to become aware of their own thought processes and strategies. A first step is to select a relevant topic for the students to reflect upon. Tanner (2012) provides an extensive list with possible questions, which can serve as a starting point, but can also feel overwhelming. In our view, reflection topics should be grounded within the activity the students engage in and be identified by practitioners. It is important for the students to feel that the prompts are coupled to something that they experience and feel is meaningful to reflect upon. We have proposed four categories of diary questions (Figure 1: what has happened? How did you approach the situation? Why is it important? How did you learn from it?) in this study that offer a starting point for educators to design their own prompts around topics relevant for their context. In order to avoid that students get tired of writing the diaries or filling them out mechanically, it is important to have variation within the prompts given to the students each week, while still providing some familiarity each week to facilitate writing (Jarvis, 2001; Moon, 2003).

Using carefully designed prompts is, however, not enough, and the introduction and framing of reflective diaries towards the students is a crucial aspect. It cannot be assumed that students are used to write reflective text and readily know what to do (English & Kitsantas, 2013). Our interview data illustrates how students' previous experiences and their conceptions of knowledge and learning can pose strong obstacles for them to engage in reflective writing. Some students might not see reflective writing as part of their learning experience at the university, as they have never encountered it before and have difficulties to relate to it. These students might hold a view of knowledge being absolute and focus on specific knowledge to be either right or wrong (Felder & Brent, 2004); a view that is difficult to maintain when engaging in reflective practice. The students require the right guidance and support to overcome this internal conflict that they describe during the interviews. It is not enough to provide the students with prompts and tell them the purpose of writing reflective diaries. Based on our own experience and data, one important factor is that the students need the possibility and encouragement to write reflective diaries over a longer period of time to fully appreciate them and benefit from them. The extended engagement in reflective practice also helps the students to get to know the person reading the diaries and developing a trust relationship, which is very important to be able to openly reflect (Walker, 2006). Other important factors that help the students are modeling of reflective thoughts by teachers (Tanner, 2012) and receiving feedback on their text (Moon, 2003; Walker, 2006).

Reflective diaries can also be used for probing student learning, as shown in the results section. For the probing dimension, it is important to consider how the information will be used, which can be roughly divided into: probing for development and probing for research. Probing for development aims at improving a course, project, or activity by helping the teacher to see it from the students' point of view. In this case, the information will stay within the university with limited access for other people. Probing for research, on the other hand, aims at using the reflective diaries to help answer research questions, and the goal is to publish the anonymized data in a research context. This means that research ethics need to be considered (Rieman, 1993), and while rules and guidelines might differ around the world, we feel that it is important

to inform the students about the research and ask them for permission to use their accounts before introducing reflective dairies.

In this paper, we have shown the potential of reflective diaries for promoting and probing student learning. From a CDIO standpoint, this is very interesting, as it can support students to become self-regulated learners and fully benefit from active learning environments created within the CDIO syllabus. Reflective diaries can help students to have *integrated learning experiences* (Standard 7: Crawley et al., 2014) by facilitating the integration of disciplinary and personal knowledge and skills, as well as provide an additional aspect to *active learning* (Standard 8: Crawley et al., 2014). Furthermore, the diaries can support the *enhancement of faculty competence* (Standard 10: Crawley et al., 2014) through the ability to probe and study student learning, and could also be used for *learning assessment* (Standard 11: Crawley et al., 2014), especially for formative assessment that support student learning (Moon, 2003). We hope that the research-based guidelines provided in this paper will help practitioners to implement reflective diaries in their own context for promoting and probing student learning.

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BIOGRAPHICAL INFORMATION

Patric Wallin is a Researcher at the Division of Engineering Education Research at Chalmers University of Technology, Gothenburg, Sweden. He holds a Ph. D. degree in Bioscience with a specialization in Educational science. He has tutored projects in the Tissue Engineering course for several years. Patric's research interests in the EER field are focused around personal development, undergraduate research experiences, communities of practice and situated cognition. He is particular interested in the progress and development processes students experience in these learning situations.

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Julie Gold is Associate Professor at the Division of Biological Physics at Chalmers University of Technology and is vice head of the Department of Applied Physics responsible for graduate education. Her research is within the fields of biomaterials and tissue engineering, with particular focus on cell-material surface interactions. She created and heads the Biomaterials & Tissue engineering track of the Biotechnology Masters Program. Julie started the Tissue Engineering course in 2005, together with Paul Gatenholm, and has continued to develop, teach, and examine the course since then.

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