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Getting through the exam: A case study of four Finnish and German students' self-regulated learning of university mathematics

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The institutional settings at universities offer students a lot of freedom to shape their own learning, which is also associated with many difficulties, especially in mathematics. From a self-regulated learning perspective and based on interviews with four students from two different countries, we qualitatively describe similarities and differences in students' learning of mathematics at university who all shared the common goal of getting through the exam. Results show that despite this common goal, the self-regulated learning of mathematics of the four analysed students differed heavily. However, similarities could be found in the importance of exercise tasks as well as in social strategies. Especially the comparison of the two countries contributes to a discussion of possible impacts of pedagogical interventions.

Keywords: Teachers' and students' practices at university level, assessment practices in university mathematics education, self-regulated learning.

STUDENTS SELF-REGULATED LEARNING IN THE TRANSITION FROM SCHOOL TO UNIVERSITY MATHEMATICS

According to Finnish and German study regulations of mathematics study programmes, about two thirds of the time scheduled for mathematics modules is assigned to students' self-study. However, there is remarkably low evidence on how mathematics students self-regulate their learning in such self-study phases. In light of students' difficulties in transitioning from school to university in mathematics (Gueudet & Thomas, 2020), universities have developed various support measures and curricular adaptations to assist students' mathematical learning and to reduce the transition difficulties (Biehler et al., 2021; Lawson et al., 2020; Rämö et al., 2021). There is evidence that such support structures have an influence on students' self-regulated learning (Lahdenperä et al., 2022). But still, "getting through the exam" seems to be a main and sometimes the only goal for some students – instead of understanding the mathematical content (Göller, 2022; Lahdenperä et al., 2021).

In this paper, we qualitatively describe the learning of mathematics of four students, whose main goal was to "get through the exam", in terms of Boekaerts' (2011) dual processing model of self-regulated learning. In doing so we hope to understand how students could be supported in applying self-regulated learning in the undergraduate mathematics context.

THEORETICAL BACKGROUND

Self-regulated learning can be defined as "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control

their cognition, motivation, and behaviour, guided and constrained by their goals and the contextual features in the environment” (Pintrich, 2000, p. 453). This definition shows the importance of students’ goals as well as their strategies – which we define as goal-directed behaviours, thoughts, or activities – to achieve these goals in models of self-regulated learning. In terms of goals, we refer to the prominent distinction between *learning goals* which focus on increasing competence (e.g. understanding a specific proof), and *performance goals* which focus on the attainment of positive judgments (e.g. good grades, Pintrich, 2000). Self-regulated learning driven by learning and performance goals is positively linked to learning outcomes (for a meta-analysis see Schneider & Preckel, 2017). Furthermore, it is central in building mathematical competence as it is essential in problem-solving (de Corte et al., 2011) and proof-based mathematics (Talbert, 2015). With regard to students who aim at “just getting through the exam”, Boekaerts’ (2011) model which additionally takes the goal to prevent threat to well-being into account seems a promising theoretical approach and will be introduced in the following.

Boekaerts’ dual processing model of self-regulated learning

The dual processing self-regulation model of Boekaerts (2011) identifies three purposes of self-regulation: (a) expanding knowledge and skills, (b) preventing threat to the self, and (c) protecting one’s commitment. This model theorizes that learners constantly appraise learning situations and tasks for their congruence with their personal goals, values, and needs. If a student appraises the learning situation to be congruent with their personal goals, values, and needs, characterized by trust, confidence, and interest towards the learning task, they will be encouraged to commit to the task and to activate strategies that ensure the expansion of knowledge and skills. Students’ learning on this *mastery pathway* can be guided by learning as well as by performance goals.

If a student appraises the learning situation as not being congruent with their personal goals, values, and needs, the learning situation poses a (potential) threat to well-being. Such a mismatch with the learning environment can occur if a task is perceived as too difficult, ambiguous, or as impairing autonomy. Accordingly, the task will be seen as an obstacle to achieving important goals such as performance or well-being and the student might activate strategies (e.g., avoidance, denial, giving up, distraction) to prevent threat and harm to the self and try to restore well-being (*well-being pathway*).

Students’ constant appraisals of the learning environment can reroute their pathways. Students may be (e.g., at first) committed to a learning task and (afterwards) experience obstacles that threaten their well-being e.g., by causing a loss of confidence or interest. Negative emotions, such as disappointment, worry, stress, anticipated embarrassment, or hopelessness will direct them towards the well-being pathway, however, they may activate strategies (e.g., suppressing these emotions, increasing effort, working harder, re-appraising the situation, focusing on the positive, seeking social support) to protect their commitment to the task and switch (back) on the mastery pathway (see Boekaerts, 2011, for a more detailed presentation of the model).

Research questions

This paper aims at qualitatively reconstructing mathematics students' self-regulated learning in terms of Boekaerts' (2011) dual processing self-regulation model in different social and cultural contexts. We thus pose the following research questions:

RQ 1: Which goals guide or constrain students' learning of mathematics?

RQ 2: Which (appraised) threats, obstacles, or mismatches in the learning environment to the achievement of these goals can be identified?

RQ 3: Which strategies do students use to achieve their goals?

While addressing these three questions, we hope to provide some ideas on how to support students in learning the skills needed in self-regulated learning and shifting from the well-being pathway to the mastery pathway (cf. Boekaerts, 2011).

METHODS

To answer these questions, we analyse interview data of four different students from two different universities (one in Finland, one in Germany) from three different research projects (Göller, 2020; Lahdenperä et al., 2021; Liebendörfer, 2018) all of whom have explicitly stated the goal of "surviving the course" or "getting through the exams" (no matter how well). The interviews had different foci and a length of approximately one hour. At the time of the interviews all four students had already participated in at least one math exam at university. To analyse the data we used qualitative content analysis (Kuckartz, 2019) with "goals", "threats", "obstacles", "mismatches", and "strategies" as concept-driven ('deductive') categories, which were then data-driven ('inductively') further developed. We report here the 'case-oriented analysis' (for details see Kuckartz, 2019). The given quotations were translated from Finnish or German by the authors. We shortly introduce the four students and the institutional settings they studied in.

Kim and Luca (all names changed; we use gender-neutral names, as gender is not the focus here) were higher secondary (Gymnasium) pre-service teachers at a German university with mathematics as one of two (compulsory) subjects. In line with the proposed curriculum, Kim attended two five-credits mathematics modules (elementary linear algebra, introduction to mathematical reasoning) together with mathematics majors in their first semester. Luca, who studied two years above Kim, attended two nine-credits mathematics modules (linear algebra, analysis; also in line with the proposed curriculum) together with mathematics majors in their first semester. At the time of the analysed interview in their second semester, both attended a nine-credits proof-based linear algebra (Kim) respectively analysis (Luca) course together with mathematics majors as well as a five-credits course on elementary geometry for preservice teachers (for details see Göller, 2020). All these modules consisted of lectures, where mathematical theory was introduced (i.e., definitions, examples, theorems and their proofs were presented) and exercises were handed out weekly. Students had to work on these exercises in self-study and submit their solutions which

then were corrected, graded, and discussed in a separate lesson. To pass such a module, 50 % of all exercises must have been solved correctly and a written exam had to be passed. In their first semester, Kim was among the best 10 % of those who reached points for the exercises, and an average grade in the written exams. Luca reached the 50 % of the points for the exercises in linear algebra and analysis but failed both exams. One year after the interview was conducted, Luca was no longer enrolled in mathematics.

Kuura is a mathematics major, and Tuisku is a statistics major studying a compulsory minor subject in mathematics, both studying in the Finnish university. They are both first-year students who attended a five-credit proof-based linear algebra and matrices course with mathematical content such as general vector spaces, subspaces, linear mappings, and scalar products (for more details see Lahdenperä et al., 2022). The course was implemented with Extreme Apprenticeship combining inquiry-based mathematics education with a flipped learning approach (see Rämö et al., 2021). The students started to study a new topic by solving introductory tasks. After submitting them, they attended lectures that were based on student discussions and focused on the main contents and their connections. After the lectures, the students solved more challenging problems and a new set of introductory tasks. To support students to solve the problems, they were offered guidance in an open learning space for several hours a day. Students received bonus points from completing the tasks. In Finland, exams are low stakes as students can retake them as many times as they want. Both Kuura and Tuisku received the maximum amount of bonus points (≥ 90 % of tasks completed) and got the grade 3 (out of 5, ‘good’) from the course exam.

RESULTS

In the following, we describe the four students’ self-regulated learning of mathematics at university in terms of their *goals* (RQ 1), their perceived *threats*, *obstacles*, or *mismatches* (RQ 2), and their *strategies* (RQ 3) for achieving those goals.

The case of Kim

Kim wanted to become a teacher (RQ 1). They wanted to pass the exams, wanted to “get through” (RQ 1, performance goals). They wanted to understand content which they appraised useful for them as a teacher (RQ 1, learning goal). Linear Algebra and especially proofs were not appraised as useful.

In elementary geometry I notice now at least that there is some content that I can actually use for school. And there I want to get ahead somehow. Because then I realize that I will really need it at some point. With linear algebra it’s more like, I deal with it as much as I can, and try to pass the exam somehow, but I honestly don’t care how quickly I forget it, as long as I don’t need it again for the later modules. Because I’m just interested in my profession and not really in any proofs that I’ll never need again.

Consequently, there was a mismatch between Kim’s perception of what they needed as a teacher and the contents of the linear algebra course, especially its emphasis on

proofs (RQ 2). They sometimes tried to understand the proofs of the lecture, but “failed with every proof that was longer than half a page” (RQ 2). There were several obstacles for Kim in the mathematics contents (“there are things that I can look at the definitions ten times and still don’t get anywhere”) and exercises of the linear algebra course (RQ 2). They sometimes tried to solve single exercises by themselves, but most of the work on them they did with their “math crew” of four students (RQ 3). Together they could solve less than half of the exercises (RQ 2). There were always tasks where they “haven’t found any approach at all on [their] own”, or “don’t know how to write it down.” When writing proofs, Kim was “never really sure if they’re correct”, and “with some tasks [they] don’t even understand the task.” So, before submission deadline they exchanged solutions with other students and eventually copied them (RQ 3).

These strategies were on the one hand a response to the requirements of the extent of the exercises that in their “opinion, it’s just too much time that’s required” (RQ 2):

If I wanted to solve the exercises completely by myself, let’s say the present one, I would probably need 15 hours. And I would say that’s true for 80 percent of my fellow students. And that’s just time that you can’t spend in a week like that.

On the other hand, these obstacles and strategies were not appraised as a threat for their goal to pass the exam: From their experience of their first exams, they concluded that they rather needed to comprehend the solutions of the exercises than to solve them:

it’s really not so necessary that you bring the knowledge to solve all the exercise sheets yourself, depending on what aspiration you have. But if you just want to get through like I do and you have the right people or the right ambition to kind of try to solve the exercise sheets, you can kind of get through.

In summary, although Kim experienced mismatches of the learning environment and their own goals, values, and needs as well as obstacles especially regarding proofs and proofing, they managed to stay committed to their long-time performance goals and found a way to participate in university mathematics which they were yet rather not interested in.

The case of Luca

Luca wanted to pass the exams to become a teacher (RQ 1, performance goal), describing mathematics at university as “necessary evil”. They thus needed “to get the points” (RQ 1, performance goal) on the exercises to participate in the exam. While Luca did not struggle to get these points (“Not that I get to my percentages, so that’s not a problem”), because they could rely on peers (“Someone always has something for the exercises”), their learning goals were less clear. They first described “I had planned to rework the exercises (...) and try to understand them” but experienced struggle and too much effort on doing so (RQ 2). Instead of deep understanding, Luca thus tried to understand “how to do things”, to pass the exam (RQ 1):

But now, with regard to the next exam, I definitely think that I have to practice, learn, and repeat a lot more tasks. [...] I learn for example how to calculate a path integral. [...] that

is in principle, simply for different equations yes always the same. So, I'm just looking for any patterns, because you need something, where you can hold on somehow.

Their most important strategy therefore was focusing the “how to” exercises and cutting out the proofs (RQ 3) which they appraised as being less relevant for the exam, for their understanding of theorems, and for their future goal of becoming a teacher:

It's always like that on the exercise sheet anyway. So, one task you can always cross out directly, that's the proof. Then there are three more tasks that you can solve. These are then mostly calculations and there is also usually an example somewhere.

Still facing struggle with this, Luca learned together with peers (RQ 3), what – however – mostly did not help them to better understand things (RQ 2):

So, we exchange information and also discuss with each other how we would do it. Or also explain things to each other when one has understood something that the other has not. But most of the time no one understands it anyways.

Experiencing frustration while learning, Luca also reported strategies that aimed at well-being:

I had moments where I said: now you're not in the mood anymore. Uh, then I just left it there and then at some point later I sat down to it again. [...] After two hours we just went to the canteen. Sometimes we did something afterwards. But we did something for two hours and then it was enough for us.

Following this, Luca was rarely on the mastery path i.e., the learning environment at university was mostly not congruent with their goals, values, and needs. However, the future goal of becoming a teacher led to a commitment by them to some tasks (mainly non-proof, calculation), within the bounds of compatibility with their well-being goals.

The case of Kuura

Kuura's goal for the course was to “see how it goes, as long as I pass, that's the thing” (RQ 1). However, this performance goal can be part of their first-year experience, as they later explained that “it has been very difficult to set any goals because I have [...] never studied at university before”.

Kuura's main strategy to meet their performance goal was solving the weekly tasks (RQ 3). They explained:

Solving the problems, that's it, like if you don't do them, nothing will work out. You need to work on the tasks.

They found the bonus points received from solving the tasks motivating, as they relieved performance stress in the exam and “pushed you to work hard on the tasks” found essential in passing the course. With their peers, Kuura made a weekly schedule for working on the tasks in all courses. Kuura skipped about half of the lectures (the ones in the morning) but worked actively on the tasks in the open learning space with peers and often asked help from the tutors. Kuura found the guidance supportive, as “it was easy to ask for help [...] and you didn't have to be alone with your problems”.

Interestingly, despite stating only performance goals explicitly, Kuura reported on guidance preferences that supported learning (RQ 1):

It was very important that the tutors don't give you the ready answers but more like guide you to the right direction, like show where one could start thinking [...] or so.

Later, Kuura continued:

In mathematics, you need to truly understand what's going on. And if you readily get an answer to a task then you haven't necessarily understood what was happening in the [...] proof [...]. So, it doesn't develop your own competence at all. And it is of utmost [...] on first-year courses, to you get some kind of basic knowledge and develop your mathematical thinking. And it doesn't develop through ready-made answers.

To conclude, Kuura had challenges in setting concrete learning goals, but within their performance goals, reported on activities that indicate shifting towards the mastery pathway. This is supported by the fact that Kuura reported that there was nothing hindering their studying and learning in the course. Furthermore, they described:

I got ['needs fixing' feedback] from a task and I looked at the it and I had missed one small but very central assumption [...]. And somehow, I became aware of how very important it is to do the things properly, [...] like I started to realise why mathematical proofs are just the way they are.

These types of eureka moments can be central in constructing the way towards setting learning goals and reaching the mastery pathway.

The case of Tuisku

Tuisku acknowledged that there is a possibility for setting learning goals, as they stated that “[this course] is compulsory for statistics students and it's obviously compulsory for a reason”. However, they reported mainly performance goals, as “the aim was of course to pass the course”, and as they found collecting the bonus points motivating, they had set a goal for the percentage of completed tasks (RQ 1).

In addition, engaging in social interaction can be considered Tuisku's goal for the course and for their university studies in general (RQ 1). However, Tuisku's general experience at the university was nothing but individualised (RQ 2). They stated that at university, “it feels like a student is just a person in an enormous mass that is just transferred through the courses”. For this reason, they greatly valued and engaged in social interaction while learning. For example, they said that “for me, it is important to work together with peers [...] as after all, the studies provide very little sense of community”.

On the one hand, their goal for engaging in social interaction supported certain strategies for achieving their performance goals: Tuisku found the tasks challenging (RQ 2) and relied on peers and tutors to solve them (RQ 3). They stated:

We sat in the [open learning space with friends] and for almost every task, we asked help from the tutor. [...] The tutors were really nice, [...] and the atmosphere very supportive.

On the other hand, the goal for engaging in social interaction also hindered certain strategies for achieving their performance goals: For example, Tuisku had recognized the tasks as difficult, and they realised there was a need to attend the lectures. However, “when my closest friends didn’t attend them, I didn’t go either”. Also, Tuisku could have missed skills to work on the tasks individually, as “if you didn’t finish [the tasks in the open learning space], you didn’t get back to them so easily at home” (RQ 3).

For reaching the goal of certain amount of bonus points, Tuisku was optimising their limited time. For example, they stated:

The one point you get from a task is of different value in different tasks in terms of time. Like right away when you see that this is an easier but laborious task [...], it gives you this feeling that timewise, this doesn’t pay off.

To conclude, the performance goal for bonus points prevented them from learning as it was more convenient to optimize their time management and stay on the well-being pathway. In contrast, Tuisku’s performance goals for passing the course supported them in finding ways to complete the tasks perceived as difficult. This supported them in shifting from the well-being pathway to the mastery pathway. The goal for social interaction was acting in both directions; on the one hand, it had a central supportive role in learning as it helped Tuisku in solving the tasks, and on the other, a central role in hindering learning as they sometimes chose peers over what could have been more beneficial for their own learning. Overall, Tuisku was on the well-being pathway trying to shift to the mastery pathway. It can be hypothesised that they were eventually successful in shifting as they already here recognised that “perhaps my way of going through the things was in the end not optimal”.

DISCUSSION

In order to qualitatively describe mathematics students’ self-regulated learning, we analysed interviews with four students from two different institutional settings in Finland and Germany. A central result of this analysis is that, although we focused on four students who share the (seemingly similar) common goal of simply getting through the exams, the self-regulated learning of the analysed students differed in many ways. Kim’s and Luca’s primary goal was to become a teacher. Both experienced mismatches in the learning environment with their personal goals (proofs, appraised usefulness of the content for schoolteachers). However, while Kim’s ambition helped them to stay committed to their long-time performance goals and to (at least partly) participate in university mathematics, Luca did not seem to get beyond the goal and strategy of looking for patterns of “how to do things”. Kuura valued strategies aimed at deeper learning and (possibly therefore) seemed to experience less mismatches in the learning environment with their personal goals, values, and needs. For Tuisku, the goal for engaging in social interaction was central which supported strategies that involved collaboration with peers and tutors, but also hindered them to engage in strategies with less social interaction. In summary, these examples highlight the importance of the orchestration of different goals, individually appraised mismatches,

and activated strategies (beyond the shared performance goal of passing the exam) for the qualitative details of self-regulated learning of mathematics at university which are anticipated in Boekaerts' (2011) model, but not specified in such detail.

Beneath these differences, there were some commonalities found which apply to all four students: Firstly, the exercise tasks take the most prominent part in the regulation of students' learning of mathematics (cf. Göller, 2022). In particular, it can be observed that some students select specific tasks in accordance with their performance goals, which underlines the importance of exam tasks for self-regulated learning processes. Secondly, all four students worked with others to solve the exercises. However, while it seems that in the Finnish setting it was rather easy to find suitable (institutionalised) support from tutors and peers to overcome obstacles in the tasks, the two students in the German setting mostly relied on peers who often could not help.

Implications, limitations, and outlook

Even though the self-regulated learning perspective – which we took here – focuses on individual learning processes, the influence of contextual features on students' self-regulated learning is obvious from the data (cf. Lahdenperä et al., 2022). For example, this is evident in the already discussed importance of exercise tasks which thus entail the practical potential to guide and scaffold students' learning of mathematics. On the other hand, considering the shown differences in students' self-regulated learning, especially their differences in appraised obstacles and mismatches which were found on the cognitive but also the motivational and behavioural level, institutionalised individual support structures (e.g. Lawson et al., 2020) seem a promising approach to support students' learning of mathematics. They seem even more promising if they do not only address students' cognitive but also their motivational and behavioural obstacles (for hints see Göller, 2020) and enable students to co-create their learning environment in a way, they appraise to be congruent with their goals, values, and needs.

When interpreting the results, it must be kept in mind that only four students with a common goal were considered here, who studied in specific contexts which influenced their self-regulated learning. However, the results show the potential of qualitative comparisons of different institutional (and cultural) settings to reveal similarities and differences in students' self-regulated learning, also allowing insights into the potential impact of pedagogical interventions.

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