A HIDDEN – BUT INFLUENTIAL – MOTIVATION FOR LEARNING IN UNIVERSITY MATHEMATICS STUDIES

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ABSTRACT

After analyzing data from a teaching intervention in a mathematics course for engineering students, we concluded that it did not proceed as planned and decided to end it. However, a year later, an experience shed new insights into its implementation, revealing that contextual effects in higher education studies may have a significant impact on how students manage their workload in mathematics courses. What we call the ‘inheritance effect’ appears to be stronger than many well-planned teaching activities and cannot be easily guided. This paper focuses on the development of the teaching intervention, contributing to the discussion of the potential reasons behind its outcomes. Factors influencing students’ motivation to complete tasks in the mathematics course include both their perceptions of the course and students’ allocation of time. This will be discussed in relation to the teaching intervention to explain its results and offer insights into its potential.

Keywords: Engineering students, motivation, inheritance effect, time, assessment.

Introduction

There is a learning effect in higher education studies that we cannot guide, and the effect is stronger than many carefully planned teaching activities. In the present paper we will illuminate this effect, based on experiences from introducing a workbook project in a mathematics course for engineering students. In this new design, 71% of students completed less than 60% of assigned tasks, yet the following year, new students eagerly sought out the same tasks. Why?

In 2023, we introduced a new teaching design in the form of a workbook and assessment system in a mathematics course for our engineering students. The aim was to motivate the students to solve mathematics problems of their own choosing rather than being forced to do so through mandatory assignments given throughout the semester. Details of the project are presented in Rensaa and Henriksen (2025), which concluded that it did not progress as intended. Therefore, in 2024, we decided to return to the task system we previously had. This year, however, students actively inquired about the workbook tasks with an eagerness to solve them. We identified what we have called the ‘inheritance effect’, a form of student lore for the course. The present paper argues that this effect plays a pivotal role in shaping student motivation and engagement in a mathematics course, revealing the importance of peer influence in educational interventions. We begin by briefly presenting the mathematics course, the implemented intervention in 2023 and its unsuccessful result. Next, we present the wake-up call we got from students' active demand for the workbook tasks the following year and discuss its reasons. This is supported by what we had uncovered in a final survey from 2023. We conclude by summarizing some key points and emphasizing why this matters.

The mathematics course and the implemented intervention in 2023

The course

The mathematics course where we implemented the workbook and assessment plan had a lecture-based teaching design. Lectures were complemented by task-solving sessions where students worked on tasks in groups and received help upon request from a teacher present in class. The assessment format was a final written end-of-course exam. The course content included a calculus part (covering various sequences and series, as well as the Laplace transformation) and a smaller linear algebra part (introducing the main concepts). The first author was the main lecturer and the course coordinator. The task-solving component included a set of recommended tasks for each week, relevant to the current course content. Before 2023, submitting solutions to at least three out of four major assignments was mandatory. Prior experiences showed that students rarely worked with the recommended tasks but mainly focused on the mandatory assignments and working just before the final exam. The main purpose of the new plan in 2023 was to encourage engineering students to work more regularly with the content. As Korhonen et al. ask: "How to motivate students so that they work hard during the entire course, not just before exams?"(2015, p. 74). We developed a workbook containing 225 larger and smaller tasks that covered the entire syllabus. The students were thoroughly informed that 50% of the tasks on the final exam would be taken from this workbook. The book contained too many tasks to be completed immediately before the exam, so we advised the students to work on these tasks evenly throughout the semester. To balance the demands of the workbook, we reduced the scope of mandatory tasks-maintaining the same number of submissions but scaling each down by up to 40% fewer tasks compared to previous years.

The implemented intervention

Nine weeks into the 2023 mathematics course, the engineering students answered an anonymous questionnaire including an open question about their opinion of the workbook and assessment scheme, allowing them to express their views in their own words. Results were analyzed drawing on one of the most widely used theories of motivation: Expectancy–Value Theory, developed and extended by Wigfield and Eccles (2000), (2020), and applied to our project as presented in (Rensaa & Henriksen, 2025). Despite the largely positive attitude towards the scheme among engineering students, a follow-up study on the day of final exams revealed that few had completed all tasks in the workbook. We handed out and collected answers to an anonymous questionnaire before the exam started, which included a question asking students to estimate the percentage of workbook tasks they had completed. Figure 1 shows the results, illustrating the percentage of workbook tasks completed by students.

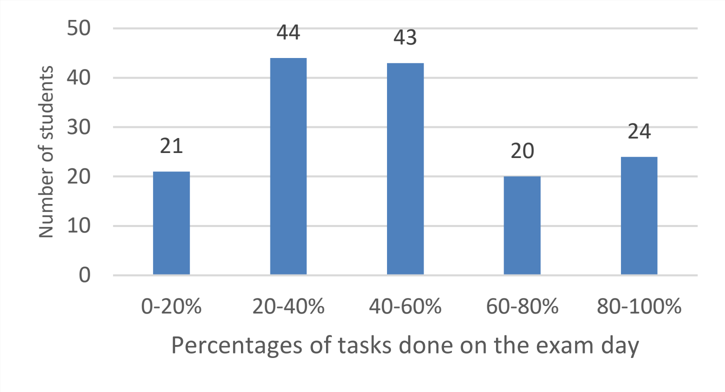

Figure 1: Percentage of tasks from the workbook completed by the 152 students who appeared for the final exam

As seen from Figure 1, most students had done between 20 and 60 percent of the tasks. Forty-four students (i.e., 29%) completed more than 60 percent, but twenty-one (i.e., 14%) completed less than 20 percent. Initially, students had intentions to do most of the tasks in the workbook, as shown in the analysis of answers from the first questionnaire (see Rensaa & Henriksen, 2025), but a minority did so in the end. Our conclusion was that the teaching design, which aimed to foster autonomy and self-motivation for task-solving, was not working as intended. Thus, the scheme was not repeated in 2024.

Some theoretical aspects

A crucial element in a mathematics course is how we assess it, since what we assess communicates what is important and what we define as valuable learning (Baird et al., 2014). Our mathematics course was assessed by a summative school exam at the end. This type of assessment is at odds with the new designs recommended in the literature. For instance, Katz (2022) highlights the variety of papers in the Primus journal exploring new assessment methods in college-level mathematics. Examples include outcome-based grading and new structures for assessing both activities, like group work, and course content by incorporating metacognitive perspectives (Katz, 2022). Summative exams are rather widespread, although French et al. (2024) concludes that there are substantial disadvantages to this type of examination. Objections include limited real-world relevance, impediments to students' self-assessment, and low reliability of exam performance. While general literature highlights students' aversion to such assessment formats, mathematics students prefer them (Iannone & Simpson, 2015). For us, the main reason for upholding summative final school examinations was the benefit of assessments in controlled environments, which reduce opportunities for cheating as possible in home exams (Rensaa, 2023). Such arguments are increasingly relevant in the age of generative AI, where powerful tools like automated problem solvers are readily available. Previously, a type of formative feedback was offered through the system of mandatory assignments, tasks that were to be solved and receive feedback on. These assignments were not a part of the students' final grade since it was not possible to verify that students solved them themselves. To improve this part, the workbook and assessment plan was introduced. We encouraged students to discuss solutions with their peers in class and seek assistance and feedback from teachers whenever necessary.

Our students were engineering students, and for such students, the time factor is crucial. Engineering studies are demanding and include a variety of laboratory activities, topics, and tasks. Researchers have raised concerns about whether engineering students are overworked (Gerrard et al., 2017). Some students focus mainly on passing exams due to the heavy workload (Korhonen et al., 2015). Furthermore, Harris et al. (2015) revealed that only a few first-year students were aware of how mathematically demanding their studies proved to be, with some admitting they might have chosen different fields of study had they known this in advance. In such a setting, motivating engineering students to prioritize mathematics is both important and challenging. Our workbook project aimed to motivate engineering students by enticing them with a final exam that had much more familiar tasks. Teaching practices and assessment are closely related, as highlighted by Pepin et al. (2021), who emphasize assessment and interactive feedback as one of four cornerstones in innovative practices for engineering students. The other three are modelling of real-world problems in mathematics, use of open-ended real-life tasks and self-regulation to encourage active student learning, and preparatory bridging courses. The latter addresses the transition gap between secondary school and university, as students are often unprepared for self-studies and self-guiding (Pepin et al., 2021).

What happened the year after the intervention year

The year after the workbook and assignment project had been implemented, evaluated, and turned down, we ran the same mathematics course again. This time we introduced another teaching project – the details are beyond the scope of the present paper – and did not present the workbook to the students in the same manner as the year before. Instead, we published selected tasks from the workbook section by section as new topics were introduced, and we returned to large mandatory assignments. No plans to select tasks from the workbook for the final exam were communicated or implemented. However, a couple of weeks after the course had started, three students approached us with the following conversation:

> Student 1: When will the workbook with all the relevant tasks for the course and the final exam be published?
> Teacher: There will be no such workbook this year, we have decided to do things differently.
> Student 2: Oh, that is a shame. We have heard from the students from last year that it is extremely important to do all the tasks in this workbook. The previous students also said that it would be important to start early on these tasks in order to manage all of them within the course frame. That is why we ask; we want to start doing the tasks as soon as possible.

This episode was the first request from students, but it was not the only time new students asked for access to the workbook. Similar requests occurred multiple times at the beginning of the course, and students explained that they had been advised by more experienced students to start solving these tasks early. The advice was to work regularly on tasks and revisit tasks from previous topics to eventually complete them all, thus being rewarded with an easier exam. Requests for workbook access diminished as students realized that the system was different this year and that the workbook tasks would not be included on the final exam.

Still, this repeated feedback from new students made us reflect on the previous intervention again and we returned to the questionnaire from the exam day in 2023. We had mostly focused on the fact that so few students had done all the tasks; this was an important reason why we dropped the workbook and assessment scheme in 2024. However, we also included an open question where students could reflect on what it would take to motivate them to complete all the tasks. Not too many students wrote anything–which is understandable before the exam–but some added comments. Many of these were positive, stating that the workbook design was well organized and that their inability to complete as many tasks as they had intended to was due to factors unrelated to the design. The time factor was cited by 18 students, who referred to a lack of time and the demands of other subjects affecting their ability to focus on mathematics. The following is an example of the latter:

> S16: Many studies have enormous project assignments. Perhaps you have to have more assignments to be able to compete with the other subjects.

We did not find any direct quotes about a lack of influence from more experienced students since the workbook project was new in 2023, but some comments could be interpreted as indirectly addressing this. For instance, some students suggested that the tasks on the exam should be more similar to those given in the workbook to increase motivation. The following is an example:

> S15: Now I haven't seen the exam, but usually these are too different from the tasks we have worked on - extra terms or tasks are added to make them 'more difficult' than the tasks in the book/booklet.

These explanations revealed a disbelief that tasks would appear in the final exam exactly as they were, without modifications. This scepticism likely would not have existed if previous students had experienced–and confirmed– that tasks were indeed quoted directly in the final exam. Even though we repeatedly informed them that 50% of the tasks would be from the workbook, students did not fully believe this. They thought tasks would come from the workbook, but some changes would be made before the exam.
The third most commented feedback, given by seven students, dealt with the number of tasks and its impact on motivation. The following is an example:

> S139: Maybe fewer tasks in the booklet; the number of tasks may seem overwhelming and students may be demotivated to start the tasks.

These students believed that 225 tasks were so many that it seemed demotivating.

Discussion

We experienced that the year after the somewhat unsuccessful workbook project, students still quite intensively requested access to the workbook. From the data presented in the previous section, there seem to be at least two reasons for this. First and foremost, there is the role of peer influence on students' engagement. This can have a direct impact on students' time management but may also influence them indirectly by being absent when a teaching intervention is first introduced. A second reason is the role of mathematics as a service subject for engineering students. It raises a discussion about how students allocate their time while studying and what influences this time-spending. Both factors influence students' motivation for mathematics.

The role of informal knowledge transfer: The impact of student lore on study priorities

The term "student lore for a course" refers to informal knowledge, advice, and opinions passed down from more experienced students to newer students about how to succeed in a specific course. This "lore" is not part of the official curriculum or guidance provided by instructors but rather consists of shared experiences, tips, and strategies that students believe are effective in succeeding in the course.

When the first students approached us with a request for access to the workbook, we were somewhat surprised. The project had been written off due to its lack of success as we had assumed assessment reliefs to work as a self-sustaining driving force and this had failed. Although the students in 2023 had been positive about the workbook system, it did not provide the intended motivation to complete most of the tasks. Only 29% of the student body had completed more than 60% of the tasks, and only 16% had completed more than 80% of the tasks. What was missing, though, was former students having experiences that could generate recommendations for what to focus on and illuminate what rewards that could be expected if completing most workbook tasks ahead of the final exam. The recommendations of experienced students had more influence than advice given by us as teachers. This shows that guidance from peers who have recently completed the course is highly valued. Experienced students know the setting and the challenges of work priorities and can therefore give advice that takes into account the overall workload of the study program. Freshman students likely assume these students have sufficient experience to know what is required to succeed – an inheritance effect (Bergqvist, 2006). It is like a type of mentorship where experiences are transferred to freshmen, an unorganized peer mentoring system. In formal forms, such mentoring typically involves senior students assisting other students and, as reviewed by Le, Sok, and Heng (2024), has many benefits. Le et al. categorize these into benefits for academic performance, retention rates, emotional and psychological well-being, and social integration. Although mentors are not necessarily older, they have significantly more experience as university students. This was what we faced: students' lore for the course guided how they wanted to prioritize their work in mathematics.

Previous research shows that assessment plays a crucial role in a mathematics course, as it communicates what is considered important and defines what we consider valuable learning (Baird et al., 2014; Pepin et al., 2021). Our workbook project was based on this assumption; the task content on the final exam would act as a lure and indirectly motivate students to do the tasks. However, simply luring them with assessment relief was clearly not enough, as indicated by the results in Figure 1 where the percentage of tasks solved by students is presented. During the implementation of the workbook project, we underlined several times that tasks would occur unchanged on the final exam. As illuminated by the statement of student S15, formulations in exam tasks were, in any case, something to be sceptical about. The student evidently had previous experience that the wording of the exam questions was different–and in the student's opinion more difficult–than what had been given in tasks during the course. This is something that students may feel even if it is not true. The tense situation of an exam can reinforce the feeling that the questions are difficult. Against such scepticism, an oral presentation of the workbook scheme by the teacher was probably not convincing enough. The students simply did not believe that half of the tasks in the exam would be picked – unchanged – from the workbook. The attainment value in terms of perceived personal importance as defined by Eccles and Wigfield (2020) was not strong enough. If such scepticism was prevalent among many students in 2023, it may have been an influential reason why the project did not succeed. What happened the year after shows how peer advice may help dispel such scepticism. Students in 2024 who asked for workbook access to do as many tasks as possible referred to the idea that the exam would be easier if they did these tasks. This was something they had learned from students who had completed the course, showing that peer advice is a stronger influence than a teacher.

The marketplace of student time: What influences how students allocate their time across courses

The term "marketplace of student time" refers to the way students must allocate their limited time among the various tasks, activities, and requirements of different courses in their education. In this marketplace, time is a finite resource that students must spend wisely to meet the demands of different courses. Each course has its own set of requirements and teachers seek to engage students in their course and encourage them to spend as much time as possible working on it. This creates a situation where students must face competing demands and make priorities. It is a challenge for students when they are imposed with so many tasks and work demands across different courses, having to prioritize which tasks to do first and which tasks to do last. Student S16 refers to this as a competition, in which courses are competing to have the students' attention. The student suggests a solution: returning to large mandatory assignments in the mathematics course, as this would 'force' students to complete tasks in mathematics. This is rather common in educational programs with high activity pressure; students are forced to prioritize work on a course by being given several mandatory assignments. In the workbook project, however, this was precisely what we wanted to move away from. Rather than forcing activity, we aimed to allure students and motivate them to complete tasks in the workbook.

Some students believed that a solution to the time constraint would be for the workbook to contain fewer tasks, as student S139 points out. This, however, could increase the possibility of memorizing solutions. Memorizing is a price to pay, or a cost value in Eccles and Wigfield's theory (2020) that we wanted to minimize as much as possible. Still, there was a risk of memorizing, but also a risk of students spending less time on mathematics since the mandatory assignments were reduced. Both issues may have been moderated if the 'inheritance factor' had been exploited in a follow-up year of the project. Students in 2024 wanted early access to the workbook and intended to work regularly with the tasks. Memorizing solutions over a longer period is challenging.

The competition between courses is found in all types of university studies, including engineering programs, where lack of time is recognized as a problem (Gerrard et al., 2017). For service subjects like mathematics, which merely provide a foundation for more program specific subjects, there is a challenge to get students to prioritize enough time to the subject since their main interest often is in the more program specific courses. For some students, the amount of mathematics courses in their engineering studies comes as an unpleasant surprise, even leading them state that they would have chosen another field of study had they know (Harris et al., 2015). Engineering students often have no higher intention than hoping to pass the exams in mathematics (Korhonen et al., 2015). In such a setting, a competition between courses for as much time as possible from each student–mathematics may be a losing party. Research has highlighted the importance of showing engineering students where and how mathematics is used in order to increase its user-value and make sense of the engineering problems ((e.g. Harris et al., 2015; Pepin et al., 2021)). Tasks related to the program in which the students have their main interest may make the competition for students' time fairer. However, as Pepin et al. (2021) have noted, applying mathematics in engineering studies poses challenges. After students have made sense of the situation, they often find the process of ‘mathematising’ difficult. This is in accordance with our experiences; students find this type of task difficult, and they may very well act more as a deterrent than as an incentive.

Conclusion

From the workbook project and its follow-up the subsequent year, at least two lessons were learned.

First and foremost, we learned not to give up the teaching intervention too early. Repeating the project would have given additional support through student lore, with advice and opinions passed down from more experienced students to freshmen about how to succeed in mathematics. This peer-to-peer effect is strong and could be further strengthened by including an end-of-course evaluation. In such an evaluation, students could be asked to describe how they would have worked with mathematics if they had their current experience when starting the course. If our workbook project had been repeated in 2024, an additional motivation to complete tasks could have been to inform students about which tasks on the previous year’s exam were taken from the workbook. It would have been important to show that these tasks were taken unchanged from the workbook since some students did not believe this. Here too, inheritance from more experienced students could have supported the argument, as their sharing of experiences would likely have included confirmation that workbook tasks were used unchanged in the final exam.

Another lesson learned was that there is a need to coordinate work requests in different courses in a study program like engineering. In particular, the amount of mandatory work must be harmonized. If the amount of mandatory work in mathematics is reduced in a project intended to foster autonomy and self-motivation for task-solving, mandatory work in other courses may easily take over. This is because students’ intentions to do tasks may be as good as any–as we concluded from the initial questionnaire in 2023 (Rensaa & Henriksen, 2025)–but when mandatory tasks and requirements arise, students are ‘forced’ to prioritize these first. This may also be a question of maturity. Maturity here refers to students’ self-discipline, as they are given the opportunity to manage their own time to a greater extent than in high school. Our students were freshmen in their first year of engineering studies. Although the mathematics course takes place in the spring semester, the students were still new to a university system and unaccustomed to the freedom to decide for themselves how to manage their time. Coming from high school, they were used to the teachers telling them what to do and when to do it. The transition from school to university is challenging (Pepin et al., 2021). Students may not yet be ready for full freedom to choose tasks at this stage. This freedom should, at the very least, be organized in a coordinated system across different engineering courses.

Afterword

It may be debatable whether the experiences and conclusions presented in this article encompass major philosophical considerations and whether it is, therefore, suitable for the journal. As Paul Ernest highlights in his review, ‘The Philosophy of Mathematics Education: State of the Art’ (2024), the growing research in this field includes extensive and fundamental philosophies addressing profound issues. Among these issues are major topics such as research methodology, ethics, and ontology. In this context, our contribution may be seen as a parenthesis that does not give large headlines. However, where is the lower limit for the 'size' of an issue to be categorized as philosophical? In other words, how small and detailed can an issue be while still fitting within the topic of 'philosophy'? This question could be the subject of a separate article and will not be discussed further here. Nevertheless, we hope that our discussion is of interest, as teachers need to reflect on the learning environments in which their students live. Whether such reflections can be categorized as 'philosophical' is ultimately for the reader to decide.

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