Learning for work: A comparative study of vocational mathematics in three contexts

Peter Frejd[1] and Karolina Muhrman[2]
[1]Department of Mathematics, Linköping University;
[2] Department of Behavioural Sciences and Learning, Linköping University

This paper explores and compares vocational students' experiences of mathematics across three teaching approaches: vocationally integrated, classroom-integrated, and textbook-based. Based on 23 group interviews with 94 students in their final year, the study investigates how these approaches influence students' perceptions of effectiveness and motivation. Students in vocationally embedded settings report stronger connections to workplace practice and higher motivation, while those in traditional settings often view mathematics as disconnected. The classroom-integrated context shows mixed results. Findings suggest that students' attitudes toward mathematics remain stable over time and are shaped by the teaching approach, highlighting the value of contextualized and collaborative methods in vocational education.

Introduction

There is broad consensus among educational researchers on the need to develop teaching strategies that connect mathematics learning to students' future professions (e.g., FitzSimons, 2001; Frejd & Muhrman, 2022). Vocational mathematics education in Sweden is designed to prepare learners for employment, yet many students struggle to see its relevance and often lack motivation (Muhrman, 2016). Research suggests that embedding mathematics in realistic workplace scenarios can enhance student engagement and make the subject more meaningful (Dalby & Noyes, 2016). However, integrating authentic scenarios into vocational mathematics education can be done in several different ways (Frejd & Muhrman, 2022). Students might, for example, explore workplace mathematics by interviewing professionals, shadowing them on the job, or engaging with realistic problems in the classroom.

This paper presents new findings from a longitudinal research project investigating how mathematics teaching approaches in vocational education can better prepare students for their future careers. The project involves nine upper secondary vocational schools across Sweden, with over 1 000 students and 20 teachers. Data is collected through pre- and post-tests, surveys, interviews, and follow-ups 18 months after the interventions. This paper shares preliminary insights from *the first follow-up interviews* that took place right before the students were leaving upper secondary school for going into work or further education. The aim is to compare students' attitudes, feelings and experiences of working with different teaching approaches at the end of their schooling, to explore their view of the effectiveness of the teaching approaches to prepare them for their future occupation. These approaches are: Context 1 (C1), a subject-integrated approach with a connection to students' professional settings; Context 2 (C2), a subject-integrated approach in the mathematics classroom; and Context 3 (C3) a traditional textbook-based approach. The analysis is guided by the following research questions:

RQ1: *To what extent do students' experiences differ regarding the perceived effectiveness of the teaching approaches in preparing them for their future professional occupation?*

RQ2: *To what extent differ students' experiences about how the teaching approaches they have encountered motivated them to learn?*

Vocational mathematics education and teaching approaches

Vocational mathematics education is shaped by diverse educational systems and apprenticeship models, resulting in varied integrations of mathematics across formal and informal settings (Wedege, 2000). Despite these differences, research suggests that effective vocational mathematics should support three interconnected forms of knowledge: *formal mathematical understanding*, *practical application in vocational contexts*, and *reflective awareness of mathematics as a tool* (Wedege, 2000). The balance between academic and workplace-oriented mathematics often reflects broader political and social priorities, but the mainstream teaching in upper secondary education focus on formal mathematics (Muhrman, 2016; Wake, 2014). To enhance relevance and quality, scholars advocate for interdisciplinary collaboration, where mathematics teachers work closely with vocational educators and professionals (Frejd & Muhrman, 2022). This cooperation helps design authentic tasks rooted in workplace practices and tools (Sundtjønn, 2021).

Authenticity is central to vocational mathematics. It involves connecting mathematical tasks to real vocational tools, traditions, and environments (Mouwitz, 2013). Studies show that learning in vocational settings, such as training halls, can boost student motivation and engagement, and reshape classroom roles and perceptions of competence (Frejd & Muhrman, 2022; Sundtjønn, 2021).

Moreover, vocational mathematics should support identity development and self-esteem by linking mathematical learning to students' professional roles and responsibilities (Mouwitz, 2013). Finally, communication and teamwork are essential workplace skills that should be embedded in vocational mathematics through collaborative tasks that reflect real-world demands (Wake, 2014).

There exist many different types of teaching approaches for developing students' mathematical skills that the need for their future occupation, which also depend on what forms of knowledge is in focus. Teachers that focus on formal mathematics might use a *Textbook-Based-Learning* (TBL) approach, similar to ones that are used in upper secondary courses in preparing for further education. Whereas as teacher focusing on mathematical applications in vocational contexts use other teaching methods. One such a teaching approach is *Subject-Integrated Team-Teaching* (SITT) (Frejd & Muhrman 2022), which is an approach where a mathematics teacher and a vocational subject teacher co-design and co-deliver instruction, often situated within or closely connected to students' training hall environments. This joint effort aims to bridge the gap between abstract mathematical concepts and their practical applications in vocational contexts.

Another integrated teaching approach is also based on interdisciplinary collaboration between mathematics and vocational teachers but takes place in the mathematics classroom. In this approach, the mathematics teacher is responsible for teaching, but the underlying ideas of the workplace situation to be discussed are developed in collaboration (Muhrman, 2016).

The extent to which these different approaches are effective in the short and long term is a matter of research. A previous study by Muhrman and Frejd (2025) found, by the end of students first year, a notable difference in students' attitudes to the teaching approaches of SITT and TBL. The SITT-group rated their experience more positively (mean score: 5.92 out of 10), appreciating the vocational relevance. In contrast, the TBL-group gave a lower rating (3.98), feeling the mathematics was less applicable.

Motivation to learn also differed, the SITT-group scored higher (4.93) than the TBL-group (3.87). Still, both groups identified positive aspects of their respective approaches. The TBL students valued small groups and clear lesson structure, while SITT students highlighted engaging lessons, varied workspaces, and practical tasks. Across both groups, the teacher played a key motivational role, alongside other factors like grades.

This paper will expand upon and contrast these findings by investigating students' experiences at the end of their final year of education, while also incorporating an integrated approach within the classroom.

The theoretical framework

This longitudinal research project is grounded in Self-Determination Theory (SDT) (Ryan & Deci, 2000), a framework for understanding human motivation in educational contexts. SDT distinguishes two main types of motivation: *intrinsic* and *extrinsic*. Intrinsic motivation is always internal, driven by interest or enjoyment. Extrinsic motivation, however, ranges along a continuum from external to internalized forms: *External*, *Introjected*, *Identified*, and *Integrated regulation*. External regulation refers to actions driven by rewards or the avoidance of punishment, while Introjected regulation involves internal pressures to maintain self-worth. Identified regulation occurs when individuals recognize the personal value of an activity, such as learning mathematics because it supports future career goals. Integrated regulation represents the most autonomous form of extrinsic motivation, where the behaviour is fully aligned with one's values and identity, such as professional identity. Intrinsic and internal motivation is associated with deeper engagement, persistence, and long-term learning outcomes (Taylor et al., 2014). By designing learning activities that support intrinsic and internal motivation, teachers can enhance both mathematical development and positive attitudes toward learning (Ryan & Deci, 2000).

Background information about the research study and data collection

As described in the introduction, the research project involves nine vocational schools across Sweden and over 1 000 students have participated in the study. This paper is based on a sub-study which included 23 group interviews with 94 students across three contexts: C1 (2 schools, 7 groups from 6 programmes, 29 students), C2 (4 schools, 8 groups from 4 programmes, 29 students), and C3 (3 schools, 8 groups from 7 programmes, 36 students). One school in the larger research project linked to C2 is not a part of this sample due to a scheduling conflict during work practice period.

Two of the schools have adopted the teaching approach connected to C1, which includes six vocational programmes. These schools allocate three one-hour lessons per week to Mathematics 1a. One of these lessons is designated as ”vocational mathematics”, which often takes place in the vocational classroom. These lessons are designed collaboratively by mathematics and vocational teachers and relate directly to students’ ongoing vocational tasks. These lessons may also require students to adhere to workplace dress codes. The remaining two lessons follow a more traditional, textbook-based format in the mathematics classroom.

The teaching approach related to C2 is applied at five schools and includes seven programs. About three hours per week is spent on mathematics education and there is a difference between the schools how much time is used for vocational education. Some of the schools work more projects based on a few vocational tasks during the semester, whereas others have more regular teaching which they also call vocational mathematics. The mathematics teacher in C2 is responsible for the teaching and planning, but has discussions and collaboration with vocational education teachers.

The sample C3 includes groups of students from three schools (whereas one school also is found in C2) covering seven vocational programmes. The mathematics instruction is delivered over three to four hours per week, primarily through textbook-based lessons. There is no collaboration between mathematics and vocational teachers in lesson planning or delivery.

To explore our research questions, semi-structured group interviews were conducted with students in their final year of upper secondary school (Year 3, 18-19 years of age). These students had been selected in their year-1 from a pool of volunteers and earlier been interviewed twice in the project. The interview guide was organized around three topics in relation to the research questions.

The first topic focused on students’ motivation to learn mathematics. Students were asked to reflect on their overall experiences with mathematics education, particularly considering that many had not studied mathematics since completing Mathematics 1a. Questions addressed their initial associations with mathematics lessons, their attitudes toward learning mathematics, and the factors that had influenced their motivation.

The second topic explored the role of mathematics in vocational work. As students had gained more practical experience since earlier stages of the study, they were also invited to discuss whether mathematics is important in their vocational area, and to provide concrete examples of how mathematics is used in workplace tasks.

The third topic addressed how mathematics education can support vocational competence. Students were asked to evaluate their teaching approach if it had prepared them for their future profession. They also reflected on the content and structure of their mathematics education, suggesting improvements that could better align with vocational needs. Finally, they were asked whether the mathematics course in Year 1 primarily served as preparation for their profession, further studies, or other goals.

The empirical material for this study consists of transcribed interviews., The interviews were analysed by a *theoretical thematic analysis* as outlined by Braun and Clarke (2006). This approach involves identifying and interpreting patterns within the data based on predefined theoretical categories, rather than generating themes inductively. We applied *nine thematic categories*. These categories reflect both practical and psychological dimensions of learning, connected to Self-Determination Theory.

For effectiveness of the teaching approaches in preparing them for their future professional occupation, the analysis focused on four categories on how students perceived the relevance of mathematics to their vocational future. This included whether they saw a *clear connection to workplace tasks*, *felt mathematically competent*, *could provide concrete examples of workplace mathematics*, and how they viewed the balance between *formal and vocational content*.

For motivation, the analysis examined students' sense of purpose in learning mathematics, including five categories about whether they *felt it was necessary* for their future profession. It also explored their *attitudes* toward the subject itself, the *variation* in teaching methods they experienced, the role of *the teacher* in supporting engagement, and the influence of *grades and assessments*.

Results and analysis

We describe the results from each context in detail below, and summarise them in a table at the end.

Context 1, vocational mathematics tasks in professional settings

The students in C1 recalled weekly lessons referred to as 'vocational mathematics', which they experienced throughout their mathematics course. These lessons were widely seen as more engaging and meaningful than traditional instruction, primarily due to their *explicit connection* to future workplace tasks. As student **S43** noted, vocational mathematics allowed them "to test everything," referring to hands-on experiences in areas like painting, housebuilding, and tinsmithing. This integration of practical tasks with mathematical concepts contributed to a sense of authenticity and relevance.

Students expressed a strong *feeling of competence*, describing themselves as mathematically qualified for workplace situations. **S54** reflected on bakery work, stating, "I think we have won a lot… it has been good for us," linking math to success in vocational exams. Students provided *concrete examples* of workplace mathematics, such as load securing (**S46**), cable dimensions (**S50**), recipe scaling (**S53**), and sight distance calculations (**S65**). These examples illustrated the *usability* of mathematics in vocational contexts, and all students agreed on its *necessity*.

Students **S59** and **S52**, suggested extending the course to two or three years, arguing that math is better learned alongside vocational practice. **S66** noted that supervisors during working practice were "not educated mathematics teachers," highlighting the need for more teaching. **S65** echoed this, saying, "Now that we have the answer, we should have wanted more vocational mathematics, even though it had not been that fun."

Students generally viewed the teaching approach as effective. **S53** stated, "this approach is good," though others suggested improvements in timing as previously discussed. Traditional lessons were often described as "boring" and more suited to academic study than vocational preparation.

Motivation was shaped by both internal and external factors. *Teachers* were frequently mentioned as central motivators, alongside *grades* and *attendance*. **S59** explained, vocational mathematics was motivating because "you will use it in the future." Attitudes toward mathematics varied: some found it "not fun" (**S47**), "not exciting" (**S43**), or difficult (**S52**), while others described it as "fun" (**S39**), "easy" (**S48**), and expressed interest in continuing mathematics studies (**S54**). Regardless of their views, all students recognized its importance for their future occupation. S41 emphasized, "Yes, it [math] is important in construction and all craft occupations."

Finally, *variation* in teaching and learning activities was seen as a motivating factor. The combination of a supportive teacher and diverse instructional methods was highlighted by **S53** as particularly effective.

Context 2, vocational mathematics tasks in the mathematics classroom

In Context 2 (C2), students' experiences with vocational mathematics were less consistent and less explicitly tied to their future professions than in C1. Several students did not recall dedicated lessons on workplace mathematics. For instance, **S69** noted, "no specific mathematics focusing on our occupation," highlighting a lack of structured integration. Some students remembered isolated examples, such as estimating hair length (**S31**) or coloring (**S30**), but emphasized that vocational math differed from classroom instruction. One student explained, "we do not use multiplication when mixing colors… we just add," and another mentioned using "cheating notes" (**S27**), suggesting a disconnect between formal math and practical use.

Despite this, many C2 students felt *confident* in their mathematics skills, often describing vocational mathematics (e.g., hairdressing, animal care, IT-support) as simple. Students gave *concrete examples* like pricing and coloring (**S27**), feeding rations and vitamins (**S80**), and medication calculations (**S90**). However, IT-support students struggled to identify specific applications, referring vaguely to programming.

Students often viewed the curriculum as geared more *toward academic* progression than vocational relevance. Many felt the mathematics taught was unnecessarily complex. **S24** remarked, "It has not much to do with what we do… we could have skipped some content." Others believed that math from grades 7–9 would have sufficed. In contrast, **S81** valued mathematics 1a, especially for those who had struggled earlier. She stressed the importance of refreshing prior knowledge and connecting it to vocational contexts: "If I start my own business, even algebra can be useful."

Suggestions for improvement included stronger links to vocational content and individualized difficulty. **S72** proposed "more tasks with specific focus to our occupation," while **S82** suggested tailoring tasks to students' skill levels.

Motivation in C2 was driven more by external factors, such as grades, attendance, and teacher support, than internal ones. A few students, like **S68**, acknowledged practical relevance of mathematics ("you need to use it"), but this view was not widespread. Attitudes varied: some enjoyed math ("I like it", **S68**), while others found it "boring" (**S28**) or "difficult" (**S83**). A recurring theme was that mathematics became enjoyable "when you understand," underscoring the importance of clarity.

Students generally agreed mathematics had some *relevance to their future* jobs, but often limited. **S27** noted tools like calculators could replace mental math, and **S28** saw mathematics as useful "such as in pricing, percent, but not mathematics as a subject, more as in economics." Unlike C1, *variation* in teaching methods was not mentioned, suggesting a more uniform and possibly less engaging experience.

Context 3, working with traditional textbook-based instruction

In C3, students primarily encountered mathematics through traditional, textbook-based instruction, with little to no integration of vocational content. None recalled consistent exposure to workplace-related mathematics. One group mentioned a single exception, a seed rate task, which they found more engaging. As **S16** noted, "[the teacher] gave us one task about seed and then it became more interesting," suggesting that even isolated vocational links could increase interest.

For most students, motivation was driven by external factors like *grades* and attendance. Comments such as "If I had not been forced to be there I would not have been there" (**S19**) and "when we were young, we learned because we wanted, but now we learn to get grades" (**S21**) reflected a lack of intrinsic engagement.

Students were generally sceptical about the *relevance* of mathematics to their future careers. Rather than citing workplace examples, they often dismissed the content as irrelevant. **S19** stated, "driving a harvester does not require knowledge about mathematics," and **S20** added, "Pythagoras' theorem and functions are not useful in the stable." Many felt the curriculum was disconnected from their occupational realities.

Several students questioned the *necessity* of the mathematics course itself, describing it as repetitive or redundant. **S19** claimed it was "just repetition of grade 9," while others argued that "grade 6 mathematics is enough to become a baker" (**S35**). **S31** summarized, "I feel that 7–9 mathematics was enough. I have never used everything we learn in upper secondary school… most things [in the workplace] are in forms where you type them in and they make all the calculations."

One student, **S9**, training to become a truck driver, offered a more nuanced view. He acknowledged that mathematics was more important than expected, noting many calculations in vocational training. However, he emphasized that these skills were learned in vocational courses, not in the mathematics classroom, which remained focused on textbook exercises.

Students consistently described the teaching approach as *monotonous and uninspiring*. **S13** remarked, "you sit and solve tasks in a textbook, tasks that you do not understand," while others used stronger language: "F… boring" (**S17**), "a complete hell" (**S20**), and "difficult and tiring" (**S24**).

Teacher quality was seen as a key factor in shaping attitudes. **S22** noted, "if the teacher is not good, you get a negative attitude towards mathematics." When asked how to improve the course, students unanimously called for more workplace-relevant content. As **S16** put it, "You get more motivated if you know that you can use it in your working life, especially if you also get to use it in practice."

Summary of analysis

The results of our analysis of the interviews are summarized in Table 1 below.

Table 1. Summary of the analysis in relation to RQ1 and RQ2, split by context (C1, C2 and C3). Y = Yes, N = No, F =Formal, V= Vocational.

RQ1,"Effectiveness"	**C1**	**C2**	**C3**	**RQ2, "Motivation"**	**C1**	**C2**	**C3**
Clear connection to workplace tasks	Y	Y/N	N	Felt it was necessary	Y	Y/N	N

A feeling of competence	Y	Y	Y/N	Attitude towards math	Mix	Mix	Neg
Provide examples of workplace math	Y	Y/N	N	Variation	Y	N	N
Formal/ Vocational focus	F/V	F/V	F	Teacher	Y	Y	Y
				Grade and assessment	Y	Y	Y

Table 1 indicates whether most students in the different groups within each context experienced the thematic categories (Yes), did not experience them (No), or if the analysis showed no clear distinction (Yes/No).

Discussion and conclusion

This study explored how different teaching approaches in vocational mathematics, (C1) subject-integrated teaching in vocational settings, (C2) subject-integrated teaching in the mathematics classroom, and (C3) traditional textbook-based instruction, influence students' perceptions of effectiveness and motivation. The findings, as displayed in table 1, reveal differences between the contexts.

Students in C1 consistently described their mathematics education as explicitly connected to their future professions. They provided concrete examples of workplace mathematics and expressed a strong sense of competence, suggesting that the integration of mathematics into vocational settings enhances both relevance and confidence. In contrast, students in C3 struggled to identify any vocational relevance, often viewing the mathematics as disconnected and unnecessary. C2 students fell somewhere in between, with some vocational connections but less consistency and clarity.

These results align with previous research (e.g., Frejd & Muhrman, 2022; FitzSimons, 2001; Dalby & Noyes, 2016), which emphasizes the importance of authenticity and contextualization in vocational mathematics. The findings suggest that students' perceptions of mathematics as a vocational tool are shaped not only by the content but also by the context in which it is taught.

The results of this study are in line with those found in Muhrman and Frejd (2025), where students filled in questionnaires at the end of their mathematics course in Year 1. In both studies, students exposed to the C1 approach reported more positive attitudes and stronger perceptions of relevance compared to those taught through textbook-based instruction. The similarity in findings suggests that students' attitudes and perceptions of mathematics tend to remain stable throughout their education. This implies that the teaching approach adopted early in their studies may have a lasting impact on how students engage with and value mathematics in vocational contexts.

The inclusion of a third context (C2) in this study adds nuance to the discussion. While not as clearly vocationally embedded as C1, C2 still offered some integration and collaboration between mathematics and vocational teachers. Students in C2 expressed mixed views, some saw relevance and usability, while others felt the mathematics was too academic or disconnected. This intermediate position highlights the importance of not only integrating vocational content but also ensuring that the integration is explicit, consistent, and meaningful to students.

There were also pronounced motivational differences. Students in C1 reported both intrinsic and extrinsic motivators. Intrinsic, internal motivation was characterised by an interest in mathematics itself. Extrinsic, internal motivation was described as driven by the relevance of mathematics to their future work. In C2, there was no intrinsic motivation, but there was extrinsic motivation driven by both internal and external factors. In C3, motivation was largely extrinsic and externally driven, with students citing grades and attendance as the main reasons for their engagement.

Across all groups, the results show that internal motivation is affected by variations in teaching methods and supportive teachers (cf. Ryan & Deci, 2000). In addition, students from all groups expressed a desire for stronger connections between mathematics and vocational practice. This shared sentiment suggests that vocational relevance is not only beneficial but necessary for meaningful mathematics education in vocational programmes. Based on these findings, it may be worth considering the development of a dedicated course in vocational mathematics, tailored to the specific needs and practices of different professions.

However, the study has limitations. One school in C2 was unable to participate in the follow-up interviews, which may have affected the representativeness of the data. Additionally, the analysis is based on qualitative coding without frequency counts, as the aim was to explore perceptions rather than quantify responses. The sample, while diverse, is still a subset of the larger intervention and should be interpreted accordingly.

Looking ahead, the next phase of the project will include a second round of follow-up interviews and further analysis of long-term outcomes.

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