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How can students in vocational education be motivated to learn mathematics?

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Abstract

The aim of this article is to discuss how mathematics teaching with a closer connection to students' vocational orientation can increase their motivation to learn mathematics. This article uses a motivation theory called self-determination theory to analyse interviews and observations made in two different studies investigating mathematics in vocational education. The results indicate that there are many vocational students who are unmotivated to learn mathematics because they do not see any relevance in the subject. However, there seem to be positive aspects regarding vocational students' motivation to learn mathematics when they are given the opportunity to work with vocational-integrated mathematics tasks, especially in a vocationally authentic environment. In relation to self-determination theory, it is possible to see increased motivation linked to a sense of meaningfulness, competence and self-determination, as well as increased social collaboration. However, teachers need to be observant of students' goals for their studies, so that even those who do not see a future in the vocation they are training for will find motivating factors for their learning in mathematics.

Keywords: vocational education, mathematics education, motivation, self-determination theory (SDT), subject integration

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Introduction

In addition to practical vocational knowledge, many vocations today require relatively extensive knowledge in general subjects such as language and mathematics. In Sweden, however, there has long been criticism from employers that vocational students have insufficient mathematical knowledge to meet the demands of working life (see e.g. Muhrman, 2016; TYA, 2015). At the same time, several reports from the Swedish National Agency for Education (SNAE) and the Swedish Schools Inspectorate (SSI) show that there are problems with vocational students' learning in mathematics, and that one of the most common reasons why vocational students do not achieve an upper secondary school diploma is that they fail in mathematics (cf. SNAE, 2003, 2017; SSI, 2010, 2017).

One reason for the poor mathematics results often cited in reports and studies is that vocational students lack the motivation to learn mathematics and therefore fail in the subject (cf. SSI, 2017). Students' low motivation to learn mathematics is explained in several studies by the fact that the connection to the profession the students are training for is weak, and that they therefore cannot see any relevance for the subject (Lindberg, 2010; Muhrman, 2016; SSI, 2017). In a review of mathematics teaching in Swedish upper secondary school, SSI (2010) states that students often lack a learning environment that creates motivation and that 'for most students, it does not seem to be the desire to learn mathematics that is missing, but the desire to learn something they do not understand and do not see the benefit of' (p. 24). The review also shows that students' attitudes towards mathematics deteriorate with monotonous teaching that is tightly controlled by a mathematics book. According to SNAE (2003), mathematics teaching becomes more monotonous and lacks variation from working with tasks in the mathematics book as students progress through school grades, meaning that many secondary and upper secondary students no longer see any concrete use for mathematics and are therefore uninterested in the subject. Many students also find it difficult to work with mathematics on a purely theoretical level, and therefore call for more realistic mathematics tasks (SNAE, 2003).

This article is based on a new analysis of data from two previous studies that are already carried out, and published (see Frejd & Muhrman, 2022; Muhrman, 2016; Muhrman & Frejd, 2018). In both studies, mathematics teaching at upper secondary vocational education and training (VET) is examined. The data consists of interviews with vocational students and mathematics teachers, as well as participatory observations in lessons where mathematics and vocational subjects are integrated. The purpose of the two studies was to understand what mathematical knowledge vocational students require in relation to the needs of professional life and how it is possible to arrange mathematics teaching that leaves them well prepared in terms of professional requirements for mathematical knowledge. This article uses a motivation theory called self-determination theory

(SDT) (Ryan & Deci, 2000) to analyse and discuss how mathematics teaching with a closer connection to students' vocational orientation can increase their motivation to learn mathematics, based on the following questions:

- Which factors do vocational students describe as being important for their motivation to learn mathematics?
- How can mathematics teaching be organised so that vocational students have increased motivation to learn mathematics?

Context of the study

In Sweden, most young people start upper secondary school the year they turn 16, after nine years of compulsory school. Upper secondary education lasts for three years. There are 18 national education programmes, of which twelve are vocational programmes and six are university preparatory programmes. All educational programmes are school-based, but vocational programmes – unlike the pre-university programmes – must include at least 15 weeks of internship at a workplace. After upper secondary education, students are expected to be ready to either start work in the profession they have studied for (if they have studied a vocational programme) or continue their studies at university (if they have completed a pre-university programme) (SNAE, 2021). The current model for upper secondary education was introduced in 2011 through a reform (Gy11) in which vocational education was more clearly separated from pre-university education. Gy11 involved vocational students no longer being automatically eligible to apply for university and the subject of mathematics being separated into three tracks with different specialisations: vocational education, social science education, and natural science education.

Between 1994 and 2011, all upper secondary programmes – regardless of specialisation – gave eligibility for further studies at university, and all students studied a common mathematics course called Mathematics A. One reason for the changes to the subject of mathematics in Gy11 can be found in Government Bill 2008/09:199, which emphasised the importance of mathematics being designed so that its content is more clearly relevant to the focus of the programme. This is because there were problems with the previous Mathematics A course, especially for vocational programmes. In reviews, many vocational students described Mathematics A as abstract and theoretical, and that they lacked motivation for the subject as they could not understand how the content of the course could contribute to competence in the profession they were studying for (SNAE, 2003; SSI, 2010)

The content of the new syllabus for vocational programmes in mathematics, Mathematics 1a, introduced in 2011 has a clearer connection to students' vocational orientation compared to Mathematics A. Despite this, both research studies and reviews show that the connection has remained weak when it comes to realisation in the classroom. Mathematics teachers who lack knowledge about students' vocational orientation find it difficult to follow the vocational content of the syllabus for Mathematics 1a in their teaching, and many students still express low motivation for mathematics as they do not understand the purpose of the subject (Muhrman, 2016; SSI, 2014).

Motivation for learning

The focus of this article is on analysing and answering questions about what can increase vocational students' motivation to learn mathematics. There is no unambiguous definition of what is meant by motivation in the research literature, but summary definitions have been proposed by various researchers. According to Jenner (2004), motivation can, for example, be explained as a driving force in relation to a goal. Motivation is not in itself a trait, but is a sum of different experiences. Several research studies show that motivation has direct significance for students' learning (e.g. Berger & Karabenick, 2011; Jungert, 2014; Murayama et al., 2013). Students' motivation for learning consists of cognitions such as what goals the students have, what they expect from their own learning, and emotions such as feelings, commitment, job satisfaction or fear of failure. This is expressed in behaviours that are seen in the form of students' concentration, attention, effort, perseverance, and choice (Berger & Karabenick, 2011; Jungert, 2014).

There are a number of different theories that can be used to explain why students are motivated or lack motivation to perform tasks, these theories concentrate on various motivational factors related to cognitions, emotions, and behaviours. For this study, the motivation theory self-determination theory (SDT) is used, which includes several different motivational factors (Deci & Ryan, 2002; Ryan & Deci, 2000). SDT distinguishes between internal and external motivation, and is based on the assumption that people are basically active actors with internal conditions to acquire knowledge, which means that their internal motivation is central to their learning. External motivation is seen as instrumental, and is about students' attitudes to learning. It is governed by external demands such as fear of penalties or anticipation of rewards such as high grades. Internal motivation, in turn, is about students having an internal drive to do tasks without the need for rewards because they find the tasks interesting and/or meaningful (Deci & Ryan, 2000; Jungert, 2014). A person is most often affected by both internal and external motivation. The type of motivation that dominates can vary over time, and varies between different people. Studies show that those who have a high degree of internal motivation work harder on their studies, invest more energy and look more positively at their studies, which benefits learning. This leads to internal motivation predicting school performance in general and being related to good study results in the long term. This is especially true for mathematics and science subjects (Taylor et al., 2014).

SDT describes three basic needs that affect students' internal motivation and that must be met for people to be motivated to learn. These are the need for autonomy – the opportunity to make your own choices, the need for competence – the opportunity to develop and feel a sense of competence, and the need for belonging – the opportunity for good relationships with friends and teachers (Deci & Ryan, 2002; Ryan & Deci, 2000).

Studies show that students who are given choices perform better and are less likely to drop out of education (cf. Otis et al., 2005). Upper secondary school students have been given a certain amount of self-determination through their choice of education. However, the need for autonomy also involves having the opportunity to make independent choices within the framework of the education regarding aspects such as content, structure, and working methods within the free space in the curriculum. However, some researchers express concern that trends of increased central control in the form of tests is reducing the free space within the curriculum and thus students' opportunities to influence teaching, which does not promote internal motivation (Skaalvik & Skaalvik, 2016).

When it comes to the opportunity to develop and feel a sense of competence, students assess their own ability based on the difficulty of tasks, expectations from the environment, and previous experiences of succeeding or failing to solve tasks (Brophy, 2010). A sense of competence has a positive correlation with higher study performance, in that students who feel competent become more motivated to perform their study tasks (Deci & Ryan, 2002; Gulikers, Runhaar & Mulder, 2018). In order to maintain students' sense of competence even when tasks become more difficult, they need to encounter tasks at the right level of knowledge for them. These tasks must not feel impossible to solve, as students can then lose both self-confidence and motivation, but must also not be so simple that the student never experiences challenges. Expectations should be high based on each person's ability, and should be positive without feeling valued (Holden, 2001).

SDT also emphasises the importance of feeling included in a group that is important to oneself (Ryan & Deci, 2000). When students are asked what they think is the best thing about being at school, a common answer is social interaction (Hofer & Peetsma, 2005). According to Leary and Baumeister (2000), the need to feel connected to a group is of great importance for students' motivation. The need to create relationships can mean that attitudes, values, and behaviours are internalised, and that students learn things that they are not really interested in, but that are important for them to be involved in the social context.

By meeting the three basic needs of autonomy, a sense of competence, and social cohesion, the degree of motivation to solve tasks can gradually increase from external motivation to internal autonomous motivation, whereby a task eventually becomes internalised and part of a person's values (Deci & Ryan, 2002; Deci & Ryan, 2008; Vansteenkiste et al., 2006).

Previous research

Studies show that motivation is more important than intelligence when it comes to succeeding in studying mathematics (Murayama et al., 2013). As described above, there are a number of factors that can affect students' motivation. Previous research shows that both the working methods and the environment in which the teaching is carried out can be important for motivation. For example, Fägerstam (2013) conducted a study with secondary-school students which showed that outdoor education can have a positive impact on students' internal motivation for mathematics. Samuelsson (2008) has also done a study in secondary school where he compared different teaching methods in mathematics teaching and concludes that work with problem solving where students are given the opportunity to discuss solutions to problems in pairs or in groups increases students' interest in mathematics compared to traditional teaching taught from the chalkboard and individual problem solving. Petersen (2011) has studied methods for mathematics teaching in upper secondary school and shows that students' motivation for mathematics can increase by the teaching based on stories where mathematics is placed in a context that students recognise. As a result, the students showed both better results and increased motivation for mathematics, but despite this, the teachers describe a stress of introducing new ways of working that means that the students do not have time to do all the tasks in the mathematics book.

Previous studies of vocational students' motivation profiles indicate that many students may have motivation problems, which can be an obstacle to building a successful professional career (Cents-Boonstra et al., 2019). Problems with motivation can also be a reason why students drop out of upper secondary education. Gidlund (2020) has studied how dropouts can be prevented through relational pedagogy. Her study shows that a good relationship with the teacher influences a student's attitude to the subject of teaching and promotes the student's learning and school attendance. Schmid et al. (2021) studied how vocational students who are particularly at risk of failing in their studies due to their social background can be kept on the 'right track'. They conclude that good relationships with teachers are crucial, as well as expectations being at the right level so that students are given the opportunity to succeed with schoolwork. Their study also shows that it is especially important for students' motivation that teachers show the relevance of schoolwork to students' lives and professional work.

Motivation for mathematics in vocational education and training

Swahn (2006), who has studied upper secondary school students' influence on teaching, states that the goals for mathematics in upper secondary education are largely motivated by the fact that students should be eligible for higher studies. This may motivate students who have planned to study further at university, but does not make the subject meaningful for those who do not have such plans (Swahn, 2006). Larsson (2014) shows that those students who choose a VET upper secondary school programme have a more negative attitude towards mathematics than those who choose a university preparatory programme. Like Schmid et al.'s (2021) study, several studies of mathematics in VET show that teaching needs to be organised so that students understand the purpose of schoolwork, because otherwise they risk becoming unmotivated to learn the subject (cf. Högberg, 2011; Lindberg, 2010). Previous research results show that a link between mathematics and vocational subjects leads to a more positive attitude among vocational students and gives them important insights into the role of mathematics in their future profession (e.g. Dalby & Noyes, 2015; Frejd & Muhrman, 2022; Muhrman, 2016).

One way to increase vocational students' interest in mathematics can therefore be to integrate mathematics with students' vocational subjects. Arguments that support a subject-integrated approach include that this can give students a deeper understanding when they can see how subjects are connected (cf. Lindberg, 2003; Lindberg, 2010; Muhrman, 2016). Research studies have also shown how a weak connection between school mathematics and vocational mathematics often makes it difficult for students to transform their mathematical knowledge from the school context to the working life context, because they have difficulties seeing a connection between them (cf. Gahamanyi, 2010; Wake, 2014). Several research studies indicate that if mathematics is taught separately from working life contexts, there is a risk of developing different 'worlds' where mathematics teaching is one world and the use of mathematics in working life is another. This can lead to students not meeting working life's demands for mathematical knowledge after their vocational education (see e.g. Bellander et al., 2017; Dalby & Noyes, 2015; FitzSimons & Boistrup, 2017; Hoyles et al., 2010; Muhrman, 2016).

In other studies of teaching within VET, however, it has emerged that many teachers in subjects such as mathematics, Swedish, and English are hesitant about subject-integrated working methods, as they believe that the subject is distorted if it is changed to a less academic orientation (cf. Muhrman, 2016). Hoachlander (1997) who has studied integration between education and work, as well as curricula, has however concluded that integrated or work life-oriented mathematics does not conflict with the high mathematical standard sought by mathematics teachers and demanded by universities. He believes that working life's expectations of employees' mathematical knowledge are often greater than many mathematics educators have realised, and that there is therefore no reason to simplify upper secondary school mathematics to suit the needs of working life. He sees great benefits in linking mathematics teaching to working life through various forms of integration; not, in the first place, for students to develop mathematical knowledge for a specific professional context, but to make mathematics more understandable and thereby increase overall mathematics learning. Vocational-integrated mathematics is thus seen by Hoachlander as a good basis for those who want to go directly into working life, as well as for those who choose to study further at university.

Previous research on mathematics in vocational education shows that students' interest in the subject can increase through subject-integrated teaching. However, research on factors that can increase vocational students' motivation for mathematics are sparse and few studies have had a direct focus on analysing vocational students' motivation-factors based on a motivation theory. This means that the results presented in this article can contribute new knowledge to the field of mathematics teaching in vocational education.

Method

This article uses data from two studies. From the first study conducted in 2012–2016, data from group interviews with 40 students (eight groups) and individual interviews with 11 mathematics teachers are used. The students and teachers come from eight different agricultural schools spread across Sweden. The interviews were of a semi-structured nature and focused on how vocational students develop the mathematical knowledge they need in relation to the profession they are training for. All the interviewed students and 67 other students also had to answer a questionnaire with questions corresponding to the interview questions, in order to see how the students answered individually and thus verify the interview answers because students can be influenced by each other when they are interviewed in groups. Like the interviews, the questionnaires were of a qualitative nature. The answers were transcribed and analysed thematically based on Braun and Clarke's (2006) model for qualitative thematic analysis.

The second study, conducted in 2016–2018, is a continuation of the first study in which the results from the first study were implemented and tested through interventions consisting of vocational-integrated mathematics tasks conducted in different contexts. The interventions were developed by mathematics teachers and vocational teachers jointly, and were carried out partly in vocational classrooms (e.g. hairdressing salons) and partly in ordinary mathematics classrooms. The outcomes of the interventions were examined through both participatory observations when the interventions were carried out, and pre- and post-interviews with teachers and students. This article uses data from the observations made during interventions for hairdressing students, during which they worked with tasks and problem solving related to cost calculations for shampooing and running a hair salon.

The purpose of the intervention study was to investigate how mathematics teachers can design vocational-integrated mathematics teaching that contributes to students' learning in mathematics and prepares them for the calculations and problem solving to be carried out in vocational life. The study also examined the significance of the learning environment for the outcome of subject-integrated mathematics teaching. Both a mathematics teacher and a vocational teacher participated in the subject-integrated lessons. During the observations, notes were taken about what was seen, with a special focus on certain points according to an observation schedule designed to include the design of the subject-integrated lessons, teachers' and students' cooperation, mathematical content, teaching methods, and students' commitment, motivation, and understanding. The observation notes were rewritten and analysed thematically based on Braun and Clarke's (2006) model, with six steps that can be briefly described, the researcher first gets to know the data properly by reading through transcripts several times. The data are then organised accordingly in initial codes. Based on the codes, patterns are sought that capture phenomena, in relation to the study's purpose and questions, and themes are created. The themes are then developed and refined by reviewing the data again and identifying the essence of what each theme is about. Using this method, three main themes were created from the thematic analysis of the two sub-studies, these themes were then jointly analysed on the basis of SDT, which developed the content of each theme and led to the creation of four sub-themes.

Different results from both studies have previously been published in a doctoral dissertation (Muhrman, 2016) and in two articles (Frejd & Muhrman, 2022; Muhrman & Frejd, 2018). However, data from the two studies have not previously been analysed together, and none of the previous publications have focused on using SDT to analyse factors that may increase students' motivation to learn mathematics, which is why this article contributes new aspects to the results from the previous publications. The data used in this article have been collected over a long period of time, and some data are a few years old. However, the author of the article has continued to conduct interviews with teachers, students, and professionals in VET in other projects, and kept up to date on the results from other research projects on mathematics in vocational education, so the data used here has been verified repeatedly and is still current.

Results

This section presents the results from the thematic analysis of the two studies, with a focus on motivational factors for vocational students to learn mathematics. The thematic analysis shows that working methods, the design of the tasks, the learning environment, and the national tests can affect vocational students' motivation to learn mathematics, which is reported under different themes. To illustrate the findings, interview quotations from the first study are interwoven with observational data from the second study.

When analysing the interview results from both the first study and the continuation study, it becomes apparent that many vocational students are unmotivated to learn mathematics. The students express in different ways that they find mathematics boring and that they have no interest in the subject, although many of them also say they understand that the subject is necessary for their future profession. According to most students, the reasons for their lack of motivation for mathematics are monotonous working methods and tasks for which they see no relevance. Most say that their mathematics teaching is dominated by individual solving of tasks in the mathematics book preceded by a lecture at the board. Several students describe the mathematics book tasks as meaningless, that they learn very little, and that they find it difficult to transform the knowledge they gain from working through the book to the calculations and problem solving carried out in the profession.

Tasks and learning environments that can give a sense of competence and create internal motivation

The relevance of the mathematical tasks is a motivating factor

According to motivation theories, the motivation to learn something is affected by the value the students see in the knowledge. It is clear from the students' interview responses that they are motivated by working with tasks for which they see relevance. For the tasks to feel more meaningful and to help the students learn the calculations and problem solving for the vocation, many students – like those in the interview quotation below – express a desire to work more with vocational-integrated mathematics tasks instead of the tasks in the maths book.

> **Erik:** It was mostly the book or booklets we had to work from.
> **Interviewer:** Would you have liked the maths to have been more focused on your future vocation?
> **All students:** Yes!
> **Erik:** It would have been easier to get involved and be motivated.
> **Anna:** If you know why you should learn it.
> **Erik:** Then you know that I will have a use for this.

Other students have had the opportunity to work with vocational-integrated mathematics to a relatively large extent. These students say that tasks they see are relevant, mean that 'they learn more, remember more and gain a better understanding of mathematics'. They also say that by working with mathematical tasks that are applied in real contexts, they can more easily use their mathematical knowledge in contexts outside school, for example in a vocational context.

> **Interviewer:** Do you think it is good to calculate such applied mathematics?
> **All students:** Yes!!
> **Filip:** It's the best maths we've done!
> **Johanna:** It's much better!
> **Interviewer:** In what way is it good, then?

> **Adam:** It's much easier to do when you know it's something you can use in real life, because it's something you'll have to do later too.
> **Johanna:** You get more motivation. It's, like, not just a case of having to learn this because you should only know it, but it's more that you should learn this so that you can know your work later.

Varied working methods and learning environments that create motivation

In order to become more motivated, the interviewed students call not only for vocational-integrated mathematical tasks as a variation from the problems in the mathematics book, but also for working methods in mathematics other than the 'traditional' individual work with tasks in the mathematics book. Most of all, students also want at least some of the mathematics lessons to be located in a practical vocational setting (e.g. a vocational classroom) instead of the mathematics classroom. The students in the quotations below have sometimes had the opportunity to have their mathematics lessons in a vocational classroom, which they would like to do more often and makes them more motivated.

> **Amanda:** If you think it's fun then you get involved instead of looking at a piece of paper, and write that I'll be here when the lesson is over. Then you just think that it will end. When you are out doing things, then you think it's fun and then you learn. I do it anyway.
> **Julia**: Because then you can't sit and sleep in your seat, but then you have to be involved.

Similar examples of how students' motivation and interest in mathematics increase when they work with mathematics in real contexts are described by several mathematics teachers. According to mathematics teacher Kristoffer, working with applied tasks can make students achieve better results in mathematics, by becoming more motivated and working harder.

> **Kristoffer:** They become interested in maths and therefore work more and therefore achieve a better result, I think. Because if I had not had such tasks, then maybe they wouldn't have done anything and then they wouldn't have achieved the result.

Students also describe how classmates who have previously shown very low motivation for mathematics suddenly become interested in the subject and start working when they are given tasks that they see are relevant to their future profession.

> **Johanna:** You notice that in the maths lessons also if you get an agriculture-related task, the boys, yes they are often boys, they are completely silent and just work, those who usually do not work.

Vocational-integrated mathematics tasks can give a sense of competence

Teachers who work with tasks applied in contexts that feel relevant to the vocational students describe how this can be of great importance for some students' ability to achieve the goals in mathematics. When the tasks are applied in a context that the students recognise, their sense of competence seems to increase, and they can solve even complicated maths tasks which they have never managed before. In addition, students' motivation increases when they see value in solving the tasks. Below, the mathematics teacher Mikael describes the significance for students' learning and motivation when they are allowed to work with tasks that are relevant to the vocation they are training for.

> **Mikael:** There I see the advantages very strongly, I remember very clearly a guy from last year, he didn't get many right in many of the tests. But he did this with passion and desire, he got a good grade for such a project. And what he did was he got some extra tasks to work out. [...] And then he calculated both equations and geometry in this, which he almost did not realise he was doing. So you can trick them into calculations just because they want to solve this practical task. Some students have such poor self-esteem in the subject of mathematics, but they can calculate in reality.

Similar results to those described in the quotation above were observed in the follow-up study, in which we compared interventions with vocational-integrated mathematics tasks in different environments. In one intervention, two of the lessons were about calculations and problem solving related to costs for various services in the hairdressing profession and the total cost of running a hairdressing salon. One lesson was conducted in the hairdressing salon. The students first had to carry out a practical task in which they shampooed each other's hair and measured the amount of shampoo used, as well as the time required, followed by calculations of the cost of shampooing in relation to running a salon. The second lesson, which was conducted in a regular classroom, included a lecture on carrying out calculations for the costs of running a hairdressing salon, followed by the students' own cost calculations for working as a self-employed hairdresser. Both lessons were given by a mathematics teacher and a vocational teacher together. When the tasks were carried out in the vocational classroom, the students took a leadership role in relation to the mathematics teacher and explained many of the vocational elements to the teacher. The students showed self-confidence that they also applied to the calculations performed after the practical task. Suddenly, they were able to make complex calculations of costs for running a hairdressing salon, including calculating hourly rates in different ways, and adding and deducting VAT in a way that they had not been able to do in previous lessons. In the post-interview discussions with the hairdressing students, they said that they especially appreciated the subject-integrated lessons in the hairdressing salon because they felt that in these lessons it was easy to see the relevance of mathematics and the mathematical knowledge they needed for their future vocation. They did not find the vocational-integrated mathematics teaching in the ordinary classroom as rewarding, as they felt that it was more difficult to understand and relate to their vocation.

Social participation in vocational-integrated mathematics can increase motivation

The observations and interviews also show that the motivational factor of social inclusion has a connection to the working methods and the environment in which the teaching is carried out. Many of the working life tasks take place in a social context, where professionals work together to solve tasks. The results of the observations in the follow-up study showed that when the mathematics lesson was held in a vocational classroom, the students collaborated in a way that reflects working life when solving the mathematics tasks. Without any encouragement from the teachers, the groups began to compare their answers with each other and discussed how and why they had solved the task in different ways. The mathematical level of the discussions was high, and the students undertook relatively advanced and complex calculations with seemingly high levels of motivation and self-confidence. During the vocational-integrated lesson in the mathematics classroom, the students' activity level was considerably lower. Few or no discussions took place between the students, and several students used their mobile phones instead of working on the task. When the students got stuck and did not understand, they sat for a long time with their hands raised, waiting for help from the mathematics teacher, instead of discussing solutions with each other.

The social inclusion and cohesion between the students were apparently much higher when the learning environment invited collaborations in which students were given the opportunity to discuss mathematical problems and get tips from both classmates and the teacher, which seemed to have a positive effect on students' motivation to work with maths tasks.

Vocational-integrated tasks are not a motivating factor for everyone

Although most students interviewed in both the first study and the continuation study expressed a desire to work with more vocational-integrated mathematics, there were also students who said that they prefer to work individually with tasks in the mathematics book. In the interviews, it emerged that these students do not usually envisage a future vocational career in the vocation they are studying for, and see vocational education mostly as a 'more fun' way of studying upper secondary education. Their plans for the future usually involve studying further at university to work in a completely different profession. A mathematics teacher who works with students studying to become horse grooms says that these students may find it boring to work with horse-oriented mathematics tasks, and that too much vocational-integrated tasks can almost lead to the students' motivation for mathematics decreasing.

> **Kristina:** I think it is important [to find the connection to the students' future vocation]. If they are genuinely interested in the vocation, it is easier to see a connection to their future vocation, then they will find motivation in this. But if they are not really interested in the vocation, there are always such students. Then it absolutely does not help to find connections and it is almost exactly the opposite, they just… ahh, no more horses!

Several teachers also talked about a possible resistance among the students when new vocational-integrated working methods are introduced. According to the teachers, this resistance may be because for many students mathematics is working with tasks in a mathematics book and some students may therefore feel insecure when new working methods are introduced. Several mathematics teachers described how students can protest and find it difficult to dare to let go of the book at first. For some students, there seems to be a sense of competence in being able to tick off every task they finish in the mathematics book and these students can be stressed when faced with new ways of working that they do not know how to handle. However, those mathematics teachers who have worked with vocational-integrated mathematics for a long time, such as the teacher in the quotation below, have noticed that this is usually only a problem initially. According to the teachers, students get used to the new working methods after a while and realise that they do not have to complete all the tasks in the book to pass the mathematics course.

> **Interviewer:** What do the students think about leaving the maths book and calculating vocationally-integrated mathematics like this?
> **Pernilla:** Yes, it's a little different, but many students think it's more fun. And you get them to understand that yes, you do not have to do all tasks in the maths book from page 1 to 130. This remains from compulsory school that you have to go through the whole book, now I have done 20 tasks it's great! But that is not the thing, the thing is that you have understood what you have done […]
> **Interviewer:** What have you noticed about the benefits of working with more applied maths then?
> **Pernilla:** They get it faster, they see relationships faster and then they work. […] Yes, they work better, if you give them this information, they really sit down and work, they can calculate a lot! And also these students who think, uhh maths is really boring. You get them on board this way.

However, it is not just the students' uncertainty or resistance that lies behind the teachers' choice of working methods. Most of the teachers interviewed chose to work with 'traditional' mathematics teaching, which is largely based on the mathematics book, despite the fact that the students often show low motivation. The reasons given by the teachers are that they have a lack of knowledge about the students' vocational orientation, which makes them feel insecure about how they should work with vocational-integrated mathematics tasks. Some teachers also say that they have such a pressured work situation that they do not have time to plan any vocational-integrated mathematics assignments and that it is then easy to use the book. They also see a sense of security in following the content of the mathematics book to know that the students get all parts of the course so they do not risk missing something that comes up in the national tests.

National tests – a factor that can negatively affect motivation

In the interviews with mathematics teachers who work with VET, the national tests are often highlighted as a reason why they do not work with vocational-integrated mathematics. In Sweden, it is mandatory for all students studying VET at upper secondary school to complete a national test in the Mathematics 1a course. The national test for mathematics is common to all vocational programmes, with general mathematics assignments without a connection to any vocational orientation. In the interviews with the mathematics teachers, it becomes clear that the national tests have a great impact on the design of the mathematics teaching. Several teachers experience stress in connection with the national tests, and feel compelled to let the students practise assignments that they know usually come up in the tests to be sure they will pass.

> **Interviewer:** How do you view the national tests, do they in any way affect your choice of working methods?
> **Mikael:** To the greatest degree! I have to teach them to handle decoded information in that way, how should I explain it now. I have to teach them to handle the questions that are put to them in exactly the way that I know they will do in the national tests.

Teachers therefore feel compelled to prioritise students' learning methods for solving specific contextless tasks assessed in the national tests, instead of learning how to use their mathematical skills to solve tasks that are relevant to their future vocation. However, despite this prioritisation, teachers describe students having difficulties understanding the contextless tasks in the national tests. The problem is not the calculations themselves, but rather the fact that the students are not able to understand what to calculate. Mathematics teacher Per says that the design of the tasks in the national tests makes some students so unmotivated that they do not even try to solve them. One year when many of his students had failed one of the major tasks in the national test, he had the students do a task with the same calculations but put it in a context that the students understood.

> **Per:** In the national test in mathematics a few years ago, I had the vehicle training class. Then they were given a task to calculate the volume of two A4 sheets of paper depending on how you fold them, and then they would do the same thing with A3 and so on. These vehicle training students could not cope with such tasks. But in the lesson after, I said that my car needed a new muffler and then they got the dimensions of the sheet metal. Everyone could figure it out. So it is so clear that it is not so much about poor maths skills but rather about motivation for work.

Some of the interviewed mathematics teachers have worked with vocational-integrated mathematics for many years. These teachers say that in recent years the national tests have increasingly become an obstacle for them to work in a way that they think is favourable for the vocational students' mathematics learning, because there has been more and more of a focus on the results of the national test governing the grading, regardless of whether the students can transform their mathematical knowledge to the vocational context in which they are educated.

> **Eva:** Exactly that! […] The tasks [in the national test], they are so far from the reality of the profession that we have worked with, so it has not agreed. […] Then I think that it is better that I work with this kind of maths that the students benefit from than that I have to work with maths that is abstract to many. […] And then I have thought that I ignore thinking about the questions in the national test. Because if I

> work like that, then they will lose interest, they don't think it's fun and then they don't care about it. I have chosen to invest in what I think they will benefit from. But now I feel that people are being questioned more and more about the results of the national tests.

It is worth adding, however, that despite the stress that many teachers feel in connection with the national tests, some teachers – such as Pernilla and Kristoffer, who are quoted above – say that their students have actually performed better in mathematics in general since they started working more with vocational-integrated mathematics. This is explained by the fact that students' motivation for mathematics has increased, which means that they work harder during the lessons, gain a deeper understanding, and learn more mathematics.

Discussion

According to self-determination theory, a sense of meaning together with the three basic needs – the opportunity for independent choices, a sense of competence, and social belonging – are decisive factors for internal motivation. When students apply to upper secondary school, they are given the opportunity to choose education that they are interested in for the first time. Based on SDT, the choice of upper secondary school could be a factor that motivates vocational students to study vocational subjects, as this is usually the reason for the choice of education. However, this choice does not include mathematics, which is a compulsory subject for all upper secondary vocational education and thus cannot be opted out from.

In order to increase motivation, most students in both studies call for more work with vocational-integrated tasks and varied working methods. Both the interviews and the observations show that working with vocational-integrated mathematics tasks can increase students' sense of competence and social participation, because these tasks invite group work and discussions more often than the maths book tasks do (cf. Ryan & Deci, 2000, 2002).

According to both students and teachers, working with vocational-integrated tasks can lead to increased understanding and in-depth learning in both mathematics and vocational subjects. The observations also showed that the environment can be important for learning (cf. Fägerstam & Samuelsson, 2014). When the hairdressing students worked with mathematics in a hairdressing salon, they radiated self-confidence and competence in the tasks, and there was considerable social activity involving the students spontaneously helping each other and discussing different solutions to the tasks at a high mathematical level. Working methods whereby students are given the opportunity to discuss mathematical problems and get tips from both classmates and the teacher increase social participation and seem to have a positive effect on both students' mathematical ability and their attitude to the subject (cf. Holden, 2001; Leary & Baumeister, 2000; Lindberg, 2003; Otis et al., 2005; Samuelsson, 2008).

However, the interviews show that working with vocational-integrated mathematics assignments does not automatically evoke a feeling of competence or internal motivation in all students. Some students become insecure when new ways of working are introduced, and a transition period may be needed to make students feel confident with the new ways of working. The interview results also show that some students do not intend to work in the profession they are training for. Students have different goals with their education, which is why the opportunity for independent choices appears to be an important motivating factor. The content of the mathematics subject is governed by the syllabus, but it includes significant free space. Within this free space, it is possible to let the selection of tasks be governed by the student's interests to some degree. For example, students can choose the extent to which they want to work with vocational-integrated mathematics tasks, depending on their goals for upper secondary studies. Working methods can also be designed so that students are given as much freedom of choice as possible. As described in the literature review, a person is often affected by both internal and external motivation that can vary over time and between different people (Taylor, 2014). The results show the continuum of internal and external motivation in students, that in different ways affect students' interest in learning mathematics (cf. Ryan & Deci, 2002). Some students think that they learn best by only working with tasks in the mathematics book. Others believe that they learn best and are more motivated if they are allowed to work with vocational-integrated mathematics tasks in the classroom or in a professional context. Some students say that they appreciate lectures and discussions with the whole class. Others say that they feel uncomfortable talking in front of the whole class and instead emphasise that they learn best and are more motivated when they work with other students in smaller groups. In order to find what motivates different students to learn mathematics, mathematics teachers therefore need to familiarise themselves with the students' perspectives and their goals for their studies, in order to give students the opportunity to make independent choices within the subject (cf. Ryan & Deci, 2002).

One factor in both studies that turned out to have a much stronger limitation on the content and design of mathematics lessons than the syllabus was the national tests. In the interviews with the mathematics teachers, it emerged that many feel compelled to work with procedure-oriented teaching with tasks similar to those in the national tests, which reduces the opportunities to work with vocational-integrated mathematics (cf. Petersen, 2012). The national tests can act as an external instrumental motivating factor for some students' learning in mathematics (cf. Ryan & Deci, 2000). In the interviews, the teachers described how students become unmotivated when working with the type of tasks that come up in the national tests, and several teachers said that they wish they could work in a more vocational-integrated manner to increase students' motivation. However, they feel that they do not have the opportunity to do so because the national tests govern the grading so strongly (cf. Skaalvik & Skaalvik, 2016). The national tests can thus be seen as a factor that risks reducing students' motivation for mathematics because students do not see any relevance in the tasks, while at the same time the possibility of making independent subject choices decreases (cf. Deci & Ryan, 2002; Högberg, 2011; Jungert, 2014; Lindberg, 2010; Schmid et al., 2021). Nevertheless, the need to adapt mathematics teaching to the design of the national tests can be questioned. Interviewed teachers who largely work with vocational-integrated teaching say that their students become better at mathematics because they are more motivated and work harder in the lessons, and thus deepen their learning. This can be compared with the reasoning put forward by Hoachlander (1997), who argues that many calculations made in working life are so advanced that vocational-integrated mathematics teaching can often maintain a high mathematical standard and can thus increase total mathematics learning in a way that prepares students for both professional work and further studies. In both the interviews and the observations, it also emerged that the students' motivation is of great importance for how advanced the mathematical tasks they undertake are. This can be compared to studies by Murayama et al. (2013), which show that motivation is more important than intelligence when it comes to succeeding in mathematics studies.

According to the results presented above, integrating mathematics with working life in different ways so that students see the relevance of the subject seems to be a motivating factor for vocational students' learning in mathematics. Regardless of how mathematics teaching for vocational students is organised, it is important to point out that most researchers in the field believe that mathematics teaching has a broader purpose than teaching students mathematics that is only useful in a certain vocational context. Lindberg (2010), Hoachlander (1997), Frejd and Muhrman (2022) and many other researchers discuss how students can get both the mathematical knowledge they need for their future profession and the general mathematical knowledge needed for everyday life and further studies. However, it is important to have a good balance so that the focus of vocational students' mathematics teaching is not only on mathematics for further studies, which risks reducing students' motivation to learn mathematics, (cf. Svahn, 2006).

Conclusion

Both previous studies and the results reported in this article show that many vocational students lack the motivation to learn mathematics. An important reason for this is that they do not see any relevance to the subject because they have difficulty linking it to their future profession. For many students, a motivating factor can therefore be to work with vocational-integrated mathematics tasks, preferably in a professional environment so that the tasks are as authentic as possible. This can increase both their sense of competence and social participation, which – together with meaningfulness – are fundamental factors for internal motivation. However, teachers should be aware that all students have different goals for their education, and for students who have not imagined a future in the vocation they are training for, it is not certain that vocational-integrated tasks will be a motivating factor. It is therefore important to give students the opportunity for different choices within the framework of the subject.

Note on contributor

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