Obstacles to learning mathematics

An interview study of what obstacles students in upper secondary school believe they encounter when studying mathematics

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Abstract

In this instrumental exploratory case study, students on the second largest programme in upper secondary school in Sweden, the Business Management and Economics Programme, were interviewed about what obstacles they believe they encountered when studying the second mathematics course. A first level of analysis, using a constant comparison method, resulted in 19 different obstacles. The seven obstacles that were uttered by the highest proportion of students were: *new content*, *more difficult*, *more work needed*, *new tests*, *faster pace*, *online school* and *problems prioritising*. In a second level of analysis, an axial coding, the codes were grouped into five larger categories: *advanced mathematics*, *managing workload*, *novel teaching*, *emotion* and *assessment*. The category that were uttered by the highest proportion of students was *advanced mathematics* which contained the obstacles *new content*, *more difficult* and *faster pace*. This study offers a base of knowledge about what obstacles students themselves express that they experience and the character of these obstacles.

Keywords

Obstacles, mathematics, upper secondary school, interviews, exploratory, case study, content, difficult, tests, pace, online, prioritise, advanced, workload, emotion, novel teaching, assessment

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Introduction

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- It is boring.
- I am not clever enough!
- I always fail, anyway…
- My teacher is bad!
- The textbook is bad.
- The pace is too fast!

If you wonder what these imaginary student statements are about, the answer is: mathematics. These comments will work as a starting point for this study, because they are important to me who dedicated my entire professional life to teaching. I have heard students making comments like these about mathematics, but I cannot recall students saying similar things about the second subject that I teach, social science. Is this strange, or not?

During my 25 years as a teacher in upper secondary school in Sweden, I have been teaching students on vocational programmes as well as on programmes preparatory for higher education. About ten years ago I had an opportunity to teach mathematics didactics at Stockholm University, on teacher training programmes. This experience made my interest in teaching and learning mathematics grow deeper. What struck me, when returning to the upper secondary school after some years, was the decline of the students' grades in mathematics in the higher courses at the Business Management and Economics Programme (hereafter abbreviated 'EP'), where I taught mathematics. I had not noticed this as explicitly earlier, and I blamed myself and my teaching for the bad results.

In this chapter, information about mathematics in the upper secondary education in Sweden will be offered, along with data showing and comparing students' achievements in different mathematics courses and other subjects, in a selection of programmes. The purpose of this in-depth background is to frame the problem that led me to conduct this study. After this section, I will present my ideas about what areas the results of this study may be sorted into, supported by earlier research. At the end of the chapter, the research question will be presented.

In-depth background

Upper secondary school

After completing ten years of compulsory school, at ages six to sixteen, almost all youth in Sweden continue their studies for another three years in upper secondary education, hereafter *gymnasium*. To qualify for the gymnasium, students need approved grades in certain subjects in compulsory school, such as mathematics, English and Swedish. In the gymnasium, there are eighteen national programmes, where six of them are preparatory for higher education and twelve are vocational (Skolverket, n.d.b).

All national programmes include mandatory mathematics courses, but the number and the content of these courses depend on the character and diploma goals of each programme. All school subjects are organised in courses, where most courses run over a school year, and generate a course grade on a six-degree scale from fail, F, to the highest pass grade, A (Skolverket, 2017). Teachers grade each student's achievements according to the knowledge requirements that the Swedish National Agency for Education, hereafter *Skolverket*, provides for each course in a subject syllabus (Skolverket, 2012, 2013).

Mathematics in the gymnasium is sorted into different courses and different levels, according to which programmes the students follow. Three different tracks for the mathematics courses are provided, the a-, b- and c-track, with at most six levels of progression. Note that there are differences in the courses following the three tracks, a, b and c, due to the differences in the programmes (Skolverket, 2012, 2013).

Programmes, tracks and courses

Vocational programmes, such as the Child and Recreation Programme and the Building and Construction Programme, follow the a-track for mathematics, and require only one course, Mathematics 1a, as mandatory. The six programmes preparatory for higher education (followed by my abbreviations) are

- Arts Programme - AP
- Business Management and Economics Programme - EP
- Humanities Programme - HP
- Natural Science Programme - NP
- Social Science Programme - SP
- Technology Programme - TP

All of these, except the NP and the TP, follow the b-track, with the courses Mathematics 1b, 2b and 3b and includes up to three mandatory courses, depending on programme and specialisation. The NP and the TP follow the c-track which require three or four mandatory courses, depending on the specialisation, and also offer Ma5 and Mathematics Specialisation (Ma-spec) as options.

The first course (Ma1a, Ma1b or Ma1c) is to a great extent a revision of compulsory school's mathematics with some programme specific features added. The content has a wide range, and includes for example algebraic expressions, linear equations, the function concept, probability and statistics. The second course (Ma2a, Ma2b or Ma2c) focuses further on algebra and functions, for example quadratic functions and equations, and includes some logic and geometry. The third course (Ma3b or Ma3c) introduces derivatives and integrals, for example. The higher courses (Ma4, Ma5 and Ma-spec.) only offer one track in common for all students who study these more advanced and specialised mathematics courses.

Students' achievements in mathematics

To know more about the EP-students declining achievements in higher courses in mathematics, national results in the gymnasium had to be examined. In order to narrow the comparisons, I chose to focus only on the two largest programmes, in terms of number of students, that contain a minimum of three courses in mathematics, that is the EP and the NP. In 2021, approximately 18,300 students started the EP and 15,400 the NP (Skolverket, n.d.c). The EP is the second largest of the university preparatory programmes and most of the EP-students take three mathematics courses that altogether make up 12% of all courses of the programme. In other words, mathematics does not constitute a peripheral subject, but is as extensive as, for example, economics.

It is easy to make generalising suppositions, such as assuming that students who choose the EP when leaving compulsory school are less interested in mathematics than students who choose the NP. Findings from Larson's doctoral dissertation (2014), where pupils in compulsory school were asked about what affected their choice of gymnasium programme, show that half of the students that chose programmes following the c-track in mathematics, that is NP or TP, stated that mathematics in school had a positive influence on their choice. Only one student out of 280 in this group answered that mathematics affected their choice in a negative way. For the group of students that applied for programmes following the b-track, for example the EP and the SP, only 14% answered that mathematics affected their choice in a positive way, whereas 22% stated that their choice was negatively affected (Larson, 2014). These results show that it is reasonable to make the kind of generalising assumption about students' opinions of mathematics as stated in the beginning of this paragraph. This has importance for understanding students' choices, however, once they start the gymnasium, the students must deal with the courses at hand to the best of their ability. Therefore, presumptions about students' initial interests had to be put aside in this study. Using existing data (Bryman, 2012), such as grade results in various courses, the students' achievements in the mathematics courses at the EP and the NP will be compared, as presented in Table 1.

Table 1. *Grade distribution (%) in upper secondary school, academic year 2020/2021, for mathematics courses in the EP (b-track) and the NP (c-track). (Skolverket, n.d.c)*

		F	**E**	**D**	**C**	**B**	**A**
Ma1	EP	0.5	28.2	22.2	25.5	13.7	9.9
	NP	0.2	8.1	12.1	22.0	23.4	34.2
Ma2	EP	8.4	39.0	19.2	19.3	8.0	6.0
	NP	1.1	17.2	15.9	26.3	19.8	19.7
Ma3	EP	21.5	37.7	14.7	14.1	6.6	5.5
	NP	3.7	19.6	15.7	21.9	16.4	22.7

When comparing the different mathematics courses one at a time, starting with the first course, it shows that quite a small proportion of the students, only 0.5% at EP and 0.2% at NP, did not pass. The corresponding numbers for the two previous years 2019/2020 and 2018/2019 were 0.7% compared to 0.2% and 0.7% compared to 0.1%, for EP and NP respectively. Still, the proportion of F's in Ma1 on EP was 2.5 times greater than on NP in 2020/2021. For the years 2019/2020 and 2018/2019, this proportion is 3.5 and 7 times greater, respectively.

Also, there are clear differences between all the grades in the grading scale on EP compared to NP, beside the differences in the grade F. The proportions of the grades along the scale from E to A almost appear to be inverse for EP compared to NP, which indicates that the performance on EP is poorer in relation to NP, in all three mathematics courses. This becomes apparent when grouping the grades into two larger groups, grades F-D and grades C-A, as shown in Table 2.

Table 2. *Grouping the grade distribution (%) in upper secondary school, academic year 2020/2021, for mathematics courses in the EP (b-track) and the NP (c-track), grades F-D and C-A. (Skolverket, n.d.c)*

	Ma1		**Ma2**		**Ma3**	
	F-D	**C-A**	**F-D**	**C-A**	**F-D**	**C-A**
EP	50.9	49.1	66.6	33.3	73.9	26.2
NP	20.4	79.6	34.2	65.8	39	61

When reviewing the Ma2 and Ma3 courses, the proportion of F's increases in both programs, compared to the Ma1 courses, as is shown in Table 1. There is a nearly eight times greater proportion of F's at the EP than at the NP in the second course. In the third course the proportion of F's at the EP is almost six times larger than on the NP. Since the minimum grade E is required to get an upper secondary school diploma, it is particularly interesting to focus on the proportion of F's.

Some students will probably not succeed in keeping up with the qualitative levels of the progression of the course described in the syllabi (Skolverket, 2012, 2013) and it seems natural that the grades tend to become lower in higher courses. With this being said, is it reasonable to assume that the distribution of students who are unable to follow the progression between the courses looks the same on the EP as on the NP? It does not seem so, judging by the statistics, which show that:

- the proportion of F in mathematics is particularly large on EP compared to NP
- the grades in mathematics are in general lower on EP compared to NP

Also, within the EP, it appears that:

- the proportion of F in mathematics is particularly large in the higher courses, Ma2b and Ma3b
- the increase in the proportion of F when moving from Ma1b to Ma2b is particularly large

Students' achievements in other subjects

When it comes to other subjects that are common for all programmes in the gymnasium, there are also differences between the grades for the EP and the NP, to the NP's advantage. However, no other subjects show as strong a negative grade development, in terms of proportions of F and change in the proportions of F between courses, as mathematics, which is shown in Sweden's Official Statistics published by Skolverket (Skolverket, n.d.c). Table 3 contains grade statistics for the courses in Swedish and English on the EP and the NP. These subjects also offer three courses (although English 7 is not compulsory). Therefore, they work well when comparing the grade development from one course to the next, in relation to mathematics. Students on the NP are still performing at a higher level than students on the EP, through all levels of grades. The proportions of the grades E, D, C and B on the EP correspond quite well to the grades D, C, B and A, respectively, on the NP, in all Swedish and English courses.

Table 3. *Distribution of grades (%) in upper secondary school, academic year 2020/2021, for the courses in Swedish and English in the economics program and the science program. (Skolverket, n.d.c)*

		F	E	D	C	B	A
Swedish 1	EP	0.1	9.2	19.6	32.9	25.3	12.8
	NP	0.1	2.8	10	25.9	31.8	29.4
Swedish 2	EP	0.8	11.4	19.6	29	23.4	15.7
	NP	0.3	4	10.5	23.7	29	32.5
Swedish 3	EP	2.6	14	19.5	26.1	21.9	15.9
	NP	1.3	5.6	12.1	22.5	28.2	30.4
English 5	EP	0.3	10.5	17.1	30.5	25.6	15.9
	NP	0.3	5.5	8	19.3	29	37.9
English 6	EP	1.1	14.4	19.8	29.6	21.3	13.9
	NP	0.9	5.9	9.2	21.4	28.6	34
English 7*	EP	4.3	13.8	20.9	28.2	20	12.9
	NP	2.6	5.6	11.6	23.4	28.6	28.2

* Not mandatory, offered as an individual choice

Roughly, the proportion of F's is about three times as large in each new course, compared to the previous one, in the Swedish and English courses on the EP and the NP (Table 3), and also in mathematics on the NP (Table 1). But the changes in grades in mathematics stand out for the EP. The proportion of F's is more than sixteen times higher in Ma2b than in Ma1b (Table 1), which makes mathematics on the EP interesting to look into. Table 4 shows the grouping of the grades, F-D and C-A, in the subjects Swedish, English and mathematics on the two programmes. As seen in this table, the results in the higher mathematics courses on the EP really stand out as different.

Table 4. *Grade distribution (%) in upper secondary school, academic year 2020/2021, for Swedish, English and mathematics on the EP and the NP for individual grades F-A and groups of grades F-D and C-A. (Skolverket, n.d.c)*

	EP						NP					
Course	**F**	**E**	**D**	**C**	**B**	**A**	**F**	**E**	**D**	**C**	**B**	**A**
Sw1	0.1	9.2	19.6	32.9	25.3	12.8	0.1	2.8	10	25.9	31.8	29.4
Group	28.9			71			12.9			87.1		
Sw2	0.8	11.4	19.6	29	23.4	15.7	0.3	4	10.5	23.7	29	32.5
Group	31.8			68.1			14.8			85.2		
Sw3	2.6	14	19.5	26.1	21.9	15.9	1.3	5.6	12.1	22.5	28.2	30.4
Group	36.1			63.9			19			81.1		
En5	0.3	10.5	17.1	30.5	25.6	15.9	0.3	5.5	8	19.3	29	37.9
Group	27.9			72			13.8			86.2		
En6	1.1	14.4	19.8	29.6	21.3	13.9	0.9	5.9	9.2	21.4	28.6	34
Group	35.3			64.8			16			84		
En7*	4.3	13.8	20.9	28.2	20	12.9	2.6	5.6	11.6	23.4	28.6	28.2
Group	39			61.1			19.8			80.2		
Ma1	0.5	28.2	22.2	25.5	13.7	9.9	0.2	8.1	12.1	22.0	23.4	34.2
Group	50.9			49.1			20.4			79.6		
Ma2	8.4	39.0	19.2	19.3	8.0	6.0	1.1	17.2	15.9	26.3	19.8	19.7
Group	66.6			33.3			34.2			65.8		
Ma3	21.5	37.7	14.7	14.1	6.6	5.5	3.7	19.6	15.7	21.9	16.4	22.7
Group	73.9			26.2			39			61		

* Not mandatory, offered as an individual choice

As shown in the sections above, it is clear that

- there is a particularly large proportion of students who fail the higher courses in mathematics at the EP, compared to the NP as well as compared to other subjects, such as Swedish and English.
- especially in Ma2b, the proportion of F in relation to the previous course, as well as to comparable courses in other subjects, is remarkably large.

What can hinder students from learning mathematics?

This study aims to investigate what could be obstacles for students learning in Ma2b. Of course, we might reason about presumed causal relationships to point out a direction for where the obstacles to students' learning in mathematics can be sought. As mentioned earlier, we may assume that the EP-students are not as interested in mathematics as the NP-students and that the former therefore are not as successful in mathematics as the latter. And, as shown above, the students on the EP get lower grades in mathematics in general and in the higher courses in specific. That being said, we must remember that the courses in mathematics were tailored to the objectives of each programme in terms of content in the courses and progression between them.

The comments students have called out in class over the years, exemplified at the beginning of this chapter, were useful in preparing for possible outcome of this study. To do this, I sorted the obstacles that I had heard students talk about into different types. One way of sorting was to divide them into internal and external obstacles (see for example Bishop, 1986; Noviani, 2021; Perbowo & Anjarwati, 2017) where factors that have to do with the students' own beliefs, attitudes, abilities, competences and efforts are labelled *internal*, or individual (Bishop, 1986), while factors outside the students' own control, such as curriculum, material, pace and teaching, are labelled *external*. A slightly adjusted way of grouping the presumed obstacles were made in this study, resulting in three areas: (1) *students' affect*, (2) *students' views on mathematics teaching* and (3) *students' views on the nature of mathematics*. The internal obstacles would correspond to the area labelled *students' affect.* The external obstacles would be divided into two areas, namely *students' views on mathematics teaching* and *students' views on the nature of mathematics*.

Students' affect

Some of the suggested matters have to do with the students' perceptions about their own ability to learn mathematics, such as their beliefs, feelings and attitudes toward mathematics, or their motivations and incentives to study mathematics. All of these aspects concern the students' affect. A common comment from students who struggle in mathematics has to do with them not identifying themselves as 'maths people'. Other examples in this area have to do with the students not believing that they are good at mathematics, not seeing themselves as clever enough, having failed previously, not being motivated, or being bored or uninterested in mathematics (see for example Cribbs et al., 2021; Grootenboer & Marshman, 2016). Through the years, I experienced different levels of self-confidence within students. These levels of confidence can help framing some of the obstacles in this area:

The confident ones. Students are often confident after achieving high grades in Ma1 or in compulsory school. But there are differences within the self-confident group. A certain kind of 'humble' confidence often coexists with high self-efficacy (see for example Bandura, 1977, 1994, 2005; Bandura & Locke, 2003). These students are driven by intrinsic motivation and possess perseverance (DiNapoli, 2018, 2019), which helps them succeed although they experience different obstacles along the way. This group of students will probably not express obstacles that have to do with affect, I would argue.

Other students that I have met show a kind of arrogant confidence, sometimes to such a degree that they, at first, think they do not need to study hard at all in Ma2b, since everything until this point has been easy. Some students even believe that they already know everything there is to know in mathematics. This kind of confidence is not very useful, and in Ma2b this 'I-do-not-need-to-study'-approach inevitably fails, and the students have to change their attitudes and actions. Others fail and fall behind without ever being able to put in the effort needed to catch up. They transfer to the non-confident group of students with low self-efficacy, where their affect becomes an obstacle.

The non-confident ones. This group also contains different types of non-confident students. Depending on their grit or perseverance (DiNapoli, 2018; Duckworth et al., 2007; Dweck, 2015), there are students who may well be hardworking and successful in developing knowledge over the course and yet appear to be non-confident and unable to notice their development or appreciate their achievements. Despite the lack of confidence, they are motivated enough to manage to finish the course.

Unlike this first group of successful but non-confident students, there are other non-confident ones who show no grit, and instead, give up easily, perhaps after an earlier failure that led to a loss of confidence. These students either fail to learn the course content or they manage to pass with a minimum margin, often after getting a lot of extra help along the way. Some of them say that they are not 'maths-people', or express anxiety towards the subject in different ways (see for example Ashcraft, 2002; Cribbs et al., 2021; Huang et al., 2019; Wang et al., 2018). There are students that hide their lack of confidence behind a mask of uninterest or bad attitude in general. These students are often so afraid of failing, that they will not even try.

The neutral ones. These students seem to adjust to the demands in the course, without revealing their confidence or emotions explicitly. If they notice that the course gets harder, they will either work harder or fail, without making any fuss about it. They do not seem to be emotion-driven, at least not in mathematics, and therefore, they do not express obstacles that have to do with their affect.

These three types of self-confidence are roughly simplified, and the descriptions do not cover all students, of course. But still, confidence seems to be a contributing factor for obstacles that have to do with students' affect.

Students' views on mathematics teaching

Some of the examples of obstacles that students have expressed during my years as a teacher have to do with the teaching, or rather, their view of it. Quite often I have heard students saying that they understood a specific topic perfectly well in class, that the explanations were clear and that they grasped the presented ideas well. But as they proceeded to work at home, they got stuck on a task, which made them give up, realising that the teaching did not provide enough knowledge. Other aspects of how the teaching is seen as obstacles are when students experience actors, materials or mediators as being 'bad', such as the teacher, the book, the design of the teaching or the tests.

When students start at the gymnasium, they bring their views on teaching after ten years in compulsory school with them, which, in my experience, can be difficult to change. Such social norms can for example constitute how teachers should ask questions and how students should answer them. The socio-mathematical norms guide teachers and students in dealing with what is normative for mathematics, for example what is seen as a good explanation or an efficient solution (Bennet & Löwing, 2015; Yackel & Cobb, 1996). Norms that presumably are agreed upon by all participants will constitute invisible classroom contracts, or didactic contracts (Blomhøj, 1994; Brousseau et al., 2020; Fuadiah et al., 2017), and violating norms or classroom contracts by making changes, will instantly be seen as an obstacle to some students. Andrews and Larson (2017) found that students have a very similar view on the structure of a typical lesson in the Swedish gymnasium. Typically, the teacher would begin by explaining concepts and procedures and show worked examples, before giving the students time to work on tasks in the textbook, mostly individually (Andrews & Larson, 2017). In my experience, the teaching in the gymnasium looks a lot like what students expect, but there are differences that might be seen as obstacles since they violate norms and didactical contracts. Firstly, an important difference, in my view, has to do with whose responsibility it is when the expected and the actual knowledge of the students do not match. Teachers in the gymnasium, or at least my colleagues and I, believe that the responsibility lies with the students to make sure that they practise as much as they need to catch and keep up with the courses. Therefore, we rarely assign homework in mathematics, as in compulsory school. Instead, students in the gymnasium are supposed to take personal responsibility for their need for practice between lessons, with the help of their textbooks (see for example Alfredsson, 2017) and other digital tools (see for example Kunskapsmatrisen, n.d.) supplied by the school. Furthermore, the mathematics tests in my school are cumulative, which is another difference that students may tussle with during the shift from compulsory school to the gymnasium. After their first year, they ought to be familiar with these, and other, changes, but I recognise students in year two who still struggle with what they see as unfamiliar settings for the teaching. This study may reveal obstacles that have to do with students' views on the teaching.

Students' views on the nature of mathematics

What is the epistemology of mathematics, its nature or character? Is it a static discipline developed on a completely abstract level? Or is mathematics dynamic and constantly changing? John Dossey (1992) discussed how the lack of a common view of the inherent nature of mathematics, its philosophy, affects both mathematical practice and teaching. Other differences in the perception of the epistemology of mathematics are presented in discussions about whether mathematics is a discovery or an invention, something which, depending on the point of view, affects the teaching of the subject (Kaijser, 2002, 2006). Discussions about whether the focus of the mathematics subject should be on products or processes can also give an idea of how difficult it is to unambiguously define the nature of the subject. When assessing students' demonstrated knowledge in mathematics, should the teacher assess the product, the process or both (Pettersson, 2010)? Teachers are probably no more in agreement on how they view the nature of the subject than researchers are, which certainly is reflected in both teaching and textbooks (Viholainen et al., 2015), and which ultimately reaches and influences the students' views on the nature of mathematics.

Linking the epistemology of mathematics to the syllabus' description of the subject, long-term goals and core content we get an idea of an epistemology for the school subject. Initially, it is written in the syllabus that, "Mathematics has a history stretching back many thousands of years with contributions from many cultures. It has developed not only out of practical necessity, but also as a result of people's curiosity and desire to explore mathematics as an end in itself." (Skolverket, 2012, p.1).

Mathematics is a cultural activity that is linked both to human needs and curiosity, that is, to practical and everyday necessities, but also to our thinking about mathematics, which, as a phenomenon on its own, is worth engaging in. But does this correlate to the students' views on the nature of mathematics? Jankvist (2015) studied how students' beliefs, understood as *views* or *images*, about mathematics as a discipline, could be changed through teaching. In his study, Jankvist found that students actually did change their images of mathematics as a discipline through teaching, at least to a measurable extent during the timeframe of the study (Jankvist, 2015). I also have a sense that a lot of students change their views on the nature of mathematics during their years in the gymnasium. The changes are hopefully driven by the slow and steady development of their understanding and to my understanding there is an implication from a change in teaching to a change in a persons' image of mathematics.

Still, there is something about mathematics, or at least school-mathematics (Lundin, 2008), that makes it more difficult to learn than other school subjects. Indeed, Cockcroft (1982) commented that mathematics "is a difficult subject both to teach and to learn" (p. 67). An important aspect of how people view the nature of mathematics has to do with the nature of the content of school mathematics. In the public debate, the question about the relevance of the mathematics content of the courses in the gymnasium is occasionally raised. Not only politicians, but also teachers sometimes express doubt about the content, or actual anxiety towards mathematics (Mouwitz, 2001) or express that the progression between courses, for example between Ma1b and Ma2b, is too big (Carlbaum, 2020). Can teachers even explain why school mathematics is important (Lundin, 2008)? In light of this, it is not surprising that students also question the usefulness of specific mathematical content, especially in the higher courses, where the level of abstraction (Gray & Tall, 2007) is high. In my experience, students tend to question other subjects' content as well, often when it gets more advanced, but I would argue that mathematics in general is more disputed than other subjects. In the annual course evaluation at the end of May, two of my students in year three commented on the question of whether they had any ideas on, or suggestions for, improvements of the teaching in the course Ma3b, in the following way:

"It is far too advanced, and there is no use of what we are working with at all, in everyday life. The result is that you do not get any motivation to study, or even try." and "Maths 3 should be dropped because it is a completely unnecessary course, which is a waste of time." (Two students in year three at the EP, 2020). These comments illustrate some students' views on the teaching and the nature of mathematics.

The research question

Students on the EP tend to achieve considerably lower grades in the two higher mathematics courses in the gymnasium than

- they do in the first mathematics course, Ma1b
- they do in Swedish and English, which are courses that also run over three years
- students on NP, who also study at least three mathematics courses

We also saw that the results are particularly weak in the second mathematics course, Ma2b.

A lot of people, such as students, teachers, school leaders and decision makers, should be interested in knowing *why* this is so. As a first step, finding what obstacles students experience in the course Ma2b could be helpful to inform further investigations. The field of research that touches upon aspects that are of interest for this study is as wide as it is rich. I have suggested three presumed areas, and maybe the students will express such obstacles for learning that fit into (1) students' affect, (2) students' views on mathematics teaching and (3) students' views on the nature of mathematics. However, realising that there should be several other obstacles than those I have heard students talk about in class over the years, this study aims to find what obstacles students themselves say that they experience, in order to contribute with new knowledge to the field.

The research question is:
What obstacles do students believe they encounter when studying the course Ma2b?

Method

The primary goal of this study was to find what students on the EP believed to be obstacles for learning when studying the course Ma2b. This chapter will outline and motivate the design and methods used to collect and analyse data to enable expounding descriptions of the obstacles and their characters. Here are also sections where I explain the setting of the study, present the participants and consider limitations due to the choice of design and methods along with some ethical issues.

Research design

This study was set as an instrumental exploratory case study. It was instrumental in the sense that I was aiming to understand the obstacles that the students thought they faced. The exploratory character emerged from the desire to develop a base for building hypotheses about the obstacles for further inquiry. The study was designed as a case study because I wanted to find what a particular unit of analysis (Merriam & Tisdell, 2015), a case, which in this study constituted a cohort of students, had to say about a specific topic.

The study aimed at advancing understanding of how ideas and abstract principles match (Cohen et al., 2018), such as obstacles and their character. These were investigated through an in-depth study with a goal which originally evolved from an interest in delimiting the bigger question of why students on the EP tend to be low achieving in mathematics.

Difficulty using existing theories and frameworks

An important reason for an exploratory design was that searching for, and taking part of, findings from earlier research led to an awareness of the broad spectrum of fields that are involved in finding and defining obstacles for learning. One consequence of this awareness was that I could not identify any particular set of pre-existing frameworks or theory formations that necessarily would fit my question. Research about how students learn mathematics and what problems can appear in learning pointed in various directions, but no one specific was found to be useful when looking for what obstacles students experience, at large or typically in the gymnasium or in the course Ma2b or corresponding. The research I found was often orientated towards specific topics in mathematics, such as functions (see for example Jannah et al., 2019) and inverse functions (see for example Perbowo & Anjarwati, 2017) or specific types of obstacles, such as cognitive obstacles (Antonijevic, 2016) or obstacles concerning specific concepts, such as threshold concepts (see for example Loch & McLoughlin, 2012; Meyer & Land, 2005). Also, much research focused on other ages of students, such as university students (see for example Tossavainen et al., 2021ab) or compulsory school students (see for example Hatisaru, 2019; Hickman & Sherman, 2019).

Difficulty using less open approach

Another reason for conducting the study with an exploratory approach emerged when thinking critically about whether there could be another, less open, approach that would be suitable. A more governed design should in my opinion be informed by rich knowledge about the subject, which in its turn could be based on experience. Teachers may well make qualified assumptions about obstacles for learning based on their experience, and as described earlier, three areas of obstacles that I had come across before might presumably appear in the result of the study. These presumed areas could have helped pointing out directions for what issues to focus the study on or helped finding suitable frameworks to use in order to examine and synthesise particular ideas further. But perhaps I would be missing out on unforeseeable aspects through such an approach. The risk of being misled by confirmation bias, or other forms of researcher biases (see for example Bierema et al., 2020; Flyvbjerg, 2013), concerning what topics to investigate or frameworks and theories to use, was too great. Since the goal was to develop understanding about what obstacles students think they experience, this led to the conclusion that the students had to be able to speak for themselves. Their voices were of importance from the very start of this study. By using an exploratory way of investigation, working under as few frames as possible and through a case study supporting in-depth knowledge about a specific group of students, this aim would be able to be reached. In sum, to achieve the purpose of this study, I argue that the approach had to be inductive, and the study had to take an exploratory shape.

Method for collecting data

To develop understanding for the obstacles that the students would offer, the descriptions of them aimed to be what is sometimes referred to as *thick descriptions* (Mills et al., 2010; Stake, 2010). Qualitative researchers achieve their interpretations through personal experiences, which could be their own or others. This experiential understanding, which by Stake (2010) is referred to as *verstehen*, the German word for personal understanding, was a part of the goal for this study. Thick descriptions of the nature of a specific phenomenon, in this case an obstacle, within a particular context (Anastas, 1999), in this case one set of interviews with one set of students, could possibly lead to *verstehen* as an outcome (Stake, 2010).

Rejecting surveys

Surveys are often used in schools, and initially, it seemed like a reasonably good choice for collecting data about what obstacles students experienced. Cohen et al. (2018) argue that it is possible to conduct exploratory surveys, without postulating assumptions in advance, and where open questions could be used to gather factual information about, for example, beliefs, attitudes and experiences (Cohen et al., 2018). But the risks and limitations were prevalent. Asking the right questions, short and effective, with a minimal risk for misinterpretation, seemed difficult, whether designing open or closed questions. Furthermore, the dropout rate could be high on the entire survey, or some questions could get a large number of non-responses (Cohen et al., 2018), or the answers could be difficult to interpret (Bryman, 2012). Other disadvantages, such as the limited possibility to provide explanations of why a certain answer is given, or how experiences change over time (Cohen et al., 2018) were in line with the most important reason to abandon the idea of a survey: I was not merely looking for a list of obstacles. Instead, I wanted to have the possibility to know if there was *something else* that could be revealed about these obstacles. This *something else* was not known in advance, and all possible findings were not predictable before the data was about to be collected (Anastas, 1999). Using surveys would be insufficient for developing in-depth understanding, or *verstehen* (Stake, 2010).

Instead, the study had to have a qualitative design and a suitable choice for collecting the data would be through interviewing a cohort of students (Bryman, 2012). The desire to answer a certain question on a factual level and at the same time look for a level of meaning is what qualitative research interviews aim at (Kvale, 2007; Kvale & Brinkmann, 2009). In this study, the factual level would be finding different obstacles for learning from the students' perspectives, and the level of meaning, the *something else* mentioned above, would mean to achieve an in-depth understanding (Bryman, 2012) of the obstacles as expressed by the students through their own experiences. In order to capture and explain such context-related phenomena (Timonen et al., 2018) as obstacles for learning mathematics for certain students in a certain course, interviews had to be used as a method for collecting data.

Qualitative interviews

Teachers engage in daily conversations with students, and interviews can be seen as conversations with well thought out structure and particular purposes. For research purposes, interviews are seen as a systematic activity which serves as a technique for collecting data (Merriam & Tisdell, 2015). In this study, it was important to allow the students to think and reflect on what obstacles they experienced, and interviews would enable me to perceive what implicitly was said between the lines as well as explicitly given answers (Kvale & Brinkmann, 2009). Also, if something was not quite clear, I had the chance to ask the students to further elaborate or explain their answers.

Considerations about interviews

Some of the standard objections to the quality of interview research that Kvale (2007) reports on were also considered as risks in this study. Firstly, as Kvale (2007) points out, the exploratory nature of the research does not lead to scientific hypothesis testing or general results. This being said, the purpose for the study was neither to test hypotheses nor to produce globally general results, why these queries were not that relevant. Secondly, interviews are questionable for not being objective or trustworthy, but rather biased, which can make the validity doubtful (Kvale, 2007). There were, of course, obvious disadvantages to knowing the participants, such as the risk of informant bias, a risk that decreases when interviewing several informants, rather than only one or a few (Mills et. al, 2010). Intrusion of the researcher's own biases, values or expectations are also a risk in interviews (Bryman, 2012). The interviewees may also have biases that influence the conversations and outcome (Merriam et al., 2015). There was also a risk concerning the power dynamics between the researcher and the participants (Brinkmann & Kvale, 2005; Mills et al., 2010). For example, there was a risk that the students would avoid mentioning obstacles having to do with the teacher or the teaching if they believed that this could be a disadvantage to them in the ongoing course.

These risks could be balanced to some extent by what I recognised as a need for the researcher to have prior knowledge about the area of investigation, especially when the interviews were planned to be open to their character. With insights into the project, through the preparatory work done in the planning phase, and in-depth knowledge (Merriam et al., 2015) about the mathematics courses, the teaching that had been conducted, the students' everyday life within the school and also by knowing the students themselves, I was certainly biased, but in an informed way. This knowledge gave me, as a researcher, greater flexibility and opportunity to consider unexpected contingencies as the interviews were conducted (Bryman, 2012; Dalen, 2013). Kvale's (2007) take on this matter was reassuring to me: "The deliberate use of the subjective perspective need not be a negative bias; rather, the personal perspectives of interviewees and interviewer can provide a distinctive and sensitive understanding of the everyday life world." (Kvale, 2007, p. 87). Nevertheless, these risks mean that the results in this study must be treated carefully.

Semi-structured interviews

Interview studies can be done in various ways. In this study, the interviews were semi-structured in the meaning that the questions were open-ended and flexible to enable expansions, changes of sequences and further follow-up questions (see for example Bryman, 2012; Cohen et al., 2018; Dalen, 2013; Kvale, 2007). They were conducted by me with my own students in the school where I work. The reasons for this choice were essentially pragmatic. Interviews with my own, fairly accessible students, could be executed in gaps in our schedules that could be negotiated with the students. Furthermore, the students knew me well and were assumed to be more comfortable in the interview situation than students who had never met me. Also, the two classes that participated constituted two thirds of all students in year three on the EP, which were a rather substantial sample in that sense.

Although the interviews had an open character, a simple interview guide (see Appendix) was prepared (Bryman 2012; Dalen, 2013; Kvale, 2007) which was used to bring a conversation that lost focus back to the questions that the study aimed to answer, for instance. With a well-planned interview guide, the interviews could contribute a rich material for the analysis. Thus, it became important to watch out for questions that could be misunderstood, be leading or require knowledge that the students did not have. With open-ended questions students would have the opportunity to present their own perceptions in their own words, also such that may not have been completely traditional (Dalen, 2013) and hence, allowing unexpected, novel findings to emerge (Bryman, 2012). It was up to the interviewer's judgement when to stick to the interview guide and when to follow up the students' answers and any new threads they may lead to (Kvale, 2007).

Group interviews

In order to effectively reach a larger number of students, interviews can be done in groups instead of individually (Cohen et al., 2018; Kvale, 2007). I planned to conduct group interviews (see for example Martínez-Sierra & García-González, 2017; Ölmefors & Scheffel, 2021) with a few students, preferably four in each group, to encourage a conversation between students, without stress and with as little interference from the interviewer as possible. The purpose was to encourage different views on the theme in focus, and the interviewer was merely to be seen as a moderator who introduces the topics for the conversation conveyed by the group members (Kvale, 2007) and prompt all group members to speak (Cohen et al., 2018). Group interviews can also generate a wider range of answers and can bring together people of different opinions, which would yield different, and complementary, versions of the topic, leading to a more complete and reliable result (Cohen et al., 2018).

Identifying and reflecting on factors that had a negative impact on one's own learning could be difficult, not least when the person was in the middle of their education. It was important to ensure that the circumstances surrounding the interviews were as simple and natural as possible so that the students were comfortable in the interview situation (Dalen, 2013), and allowing the students to have a numeric advantage towards the researcher might be valuable and help reduce some of the risks mentioned earlier. But most important was the idea that the discussions and interactions within the group would be beneficial to the study. One student's suggestion could be challenged by other participants (Bryman, 2012) as well as further elaborated on and clarified, which altogether would give a more stable and reliable result. Therefore, interviewing one student at a time would not benefit the purpose of the study, in my opinion.

When it came to the selection of students, my intention was to interview all students in the two EP-classes that I taught. That would yield 64 students, with a total of 16 group interviews, which would make the sample size large enough to achieve data saturation (see for example Guest et al., 2006;

Merriam et al., 2015; Xenofontos & Andrews, 2020). Two students were not able to attend during their groups' interviews, which meant that 62 students were interviewed. A test interview was also conducted with a group of students outside the two classes, to determine how the research instrument worked (Bryman, 2012). In this way, I was given the opportunity to adjust the questions in the interview guide and the organisation of the actual interview situation as well as test the technique to make sure that everything would work out as planned.

Group composition

The group composition was mainly done with the intention of creating groups where the students would feel comfortable so that all students would dare to make statements and have their voices heard (Kandola, 2012). This led to the decision of having the students be part of groups with other students that they knew well, rather than randomised groups, for example.

An alternative, that I thought of at first, would have been to choose groups that were either homogeneous or heterogeneous with regard to the students' demonstrated knowledge in the course Ma2b. In knowledge-homogeneous groups, students could be assumed to have similar experiences of barriers to learning. The problem with grouping the students with respect to their achievements was that it would be difficult to optimise this grouping in a reasonably easy way, without revealing the idea to the students. If students knew that they were placed in groups due to their achievements, this could make some of them feel discouraged, which could affect the study negatively. Another risk was that the conversation could be impaired if students were not comfortable with each other.

One disadvantage with group interviews mentioned in literature, is that one interviewee may dominate the conversation or that a 'group think' is created, which discourages individuals with different opinions from speaking out in front of the others (Cohen et al., 2018). But this risk should be smaller when groups are composed through friendship criteria. However, being prepared for this to happen I could easily intervene where such things occurred. For example, when a group's conversation got stuck around a certain obstacle I asked if there were any other obstacles. Or when one or two students dominated the dialogue, I asked for the silent students' opinions, also reminding them that they did not have to be unanimous.

Groups that are heterogeneous in terms of level of knowledge could, in contrast to the homogeneous groups, be at risk of generating conversations where the more high-achieving students are taking more space than low-achieving students, who may feel uncomfortable talking about their perceived obstacles in mathematics learning with their high-achieving peers. The conversations must not be dominated by one or two students, which the interviewer has to be careful about (Kandola, 2012).

Instead, if the groups were chosen to ensure that the conversation climate would be candid and the atmosphere good, there would be a fair chance that a wide range of obstacles would be presented in these conversations. Thus, the groups were chosen from the perspective of friends, where the main purpose of the grouping was for the students to experience the interview situation as safe. The group cohesion could contribute to engagement from all group members, since they would all want the group, as a unit, to be successful (Slavin, 2015). Those students who often tend to be shy, or less interested, could be supported by other group members to make contributions (Wang, 2020). The environment had to be such that the students were able to voice their opinions, knowing that they would be taken seriously and treated with respect by the other participants as well as the interviewer (Kandola, 2012). In sum, my hope was that the interviews, due to this grouping, could present both width and depth regarding the students' perceived obstacles.

Participants

As mentioned before, the interviews were conducted at the school where I work and with the students that I teach. The school is a municipal gymnasium, with about 650 students, located a few kilometres from Stockholm city. The vast majority of the students come from the surrounding areas in the same or adjacent municipalities. Since the areas where the students live are quite homogeneous considering the residents' backgrounds, such as socioeconomic structure, family constellation and whether they are native Swedes or immigrants, the group of students at my school is also quite homogeneous. In general, the students came from middle class areas, and they were born in Sweden. The 62 participants in this study were all in their third and final year on the EP. They came from two classes; one class studied the economy specialisation, and the other class studied the law specialisation. Both classes had been taught by me in all three courses. None had failed the first course and only one student had failed the second course.

Documenting the interviews

The interviews were filmed with the camera on a laptop. The students were all used to creating podcasts and movies and would probably not be particularly uncomfortable with their conversations being documented on film. With the help of the video recordings, it was easier to correctly register each student's answers, which should have made the transcripts and notes more accurate than if only audio recording were used.

Methods for analysing data

In any exploratory study, strategies for data analysis should be paramount in the mind of the researcher. Approaches that privilege the data, in this case the student voice, should take precedence. One approach to this is to adopt the analytical practices of the grounded theorists (Glaser & Strauss, 1973), which have been widely used in mathematics education research (see for example Bonner & Adams, 2012; Cobb & Jackson, 2011; Khiat, 2010; Vollstedt, 2015).

Constant comparison, memos and notes

The goal was to find and understand the main ideas and characteristics about the obstacles that were presented by the students. The results of the study were truly grounded in the data (Timonen et al., 2018). The results might in turn be related to existing research by contributing with new knowledge, and help developing hypotheses that further inquiry could distil and theorise. In order to do this, some of the tools, systematic steps and analytical processes that are used by grounded theorists, for example coding, memoing and constant comparison (see for example Cohen et al., 2018; Creswell, 2009; Merriam et al., 2015; Timonen et al., 2018) were used in the study.

The videos were to all intents and purposes transcribed, non-verbatim. Although time consuming, transcribing the interviews deepened my familiarity with the data (Merriam & Tisdell, 2015), since some time had passed after conducting the interviews. I did not transcribe sounds that I thought were irrelevant since they did not bear perceivable information, such as sighs, laughter, hmmmm’s or aahhh's. Only what was said in words was carefully noted. I also chose not to take notes on body language, such as gestures and facial expressions, since this would be too difficult to correctly interpret.

The transcriptions of each interview were read, one by one, using the iterative method of constant comparison, where memos were taken (Timonen et al., 2018) and codes were noted in spreadsheets. From each interview, the notes were read thoroughly, and whenever a statement was uttered, which I interpreted as an obstacle, this was noted as a code and associated with the student that did the utterance. This way of coding was open in the sense that it was fairly unstructured, and the endeavour was to be *open* for unexpected codes to be found in the material (Cope, 2020). All obstacles that were uttered emerged into unique codes and were noted each time they appeared. To do this efficiently, I read one student's contributions to the group conversation at a time before I moved on to studying what the next student in the same group said, and so on. In the spreadsheets, each student achieved a personal row where their uttered obstacles were noted. For each new obstacle uttered, a new column was inserted, and the code was counted for. This process was accompanied by memo-taking to help keep track of where to go back and reread in order to compare the earlier read interviews with the most recent read ones. As soon as a new obstacle occurred in a student’s utterance, I went back and re-read the ones that were already read in order to look for the new code. This procedure of constant comparison, where the researcher cycles back and forth through the data set (Timonen et al., 2018), spirals backwards (Kvale, 2007) or undertakes multiple rounds (Weinberg & Thomas, 2018), transforms the data into discrete parts to enable the analysis.

Data reduction

When starting to sort the codes in order to analyse the data, the codes were initially condensed in two ways. One way was through eliminating two codes, *thinking you got it, but you don't* and *not used to study maths much*. Not only were these obstacles vague, but each was uttered only twice. This would not contribute to the result. The second way was through a fusion of obstacles that were essentially the same. This was done for a couple of codes that were at first considered as separate: *other subjects prioritised (deadlines/more fun/easier)* and *having difficulty prioritising (personal discipline/responsibility/postponed work)*. These two obstacles were emerged into one, labelled *problems prioritising*. This resulted in 19 unique codes, one for each type of obstacle.

Further data reduction (Cope, 2020) was needed for more visible patterns to emerge. Thus, larger categories were created to host codes connected to each other. This can be seen as a type of analytical or axial coding (Merriam et al., 2015; Mills et al., 2010; Prigol & Behrens, 2019; Vollstedt & Rezat, 2019, and see for example research by Cope, 2020; Merriam & Tisdell, 2015; Xenofontos & Andrews, 2020). The chosen *axes*, along which I looked for themes in the data, were the categories, defined through the characters of the obstacles. The axial coding, where I looked for patterns, relations and meaning (Merriam et al., 2015; Mills et al., 2010; Vollstedt & Rezat, 2019) resulted in five major categories: *advanced mathematics, managing workload, novel teaching, emotion* and *assessment*. Each category included two to six codes.

Practicalities when analysing

The analysis that had begun during the coding procedure continued with several parallel processes, all accompanied by extensive memo-taking in spreadsheets and text-documents. Through this process I revisited the videos to make sure students' quotes were properly transcribed as well as the written notes from the interviews several times, and the coded data was elaborated on and organised in different ways to discover patterns. Several important choices had to be made during this process, for example:

- Should I summarise how many times a code was uttered as a total or how many students that uttered the code, or both?
- Should I summarise how many codes were uttered by each student or within each group, or both?

As shown in the section with the results and analyses, I often chose 'both' in order not to miss out on interesting and important findings. Finally, the process of analysing the data came to an end and the process of writing down the results of the study began.

Concerns about trustworthiness

The major concern about this study is whether it has been carried out in a rigorous way or not (Merriam & Tisdell, 2015). For the reader to be able to validate the trustworthiness (Bryman, 2012), I have tried to be as open and clear as possible. The design of the study and the methods used to collect and analyse the data have been thoroughly described in the sections above. Here, I will address some aspects of trustworthiness to further explain the choices made for the design and methods.

Internal validity

The students interviewed in this study served as a purposeful sample in the sense that they could contribute to in-depth understanding of a particular information-rich case, rather than giving the average opinion of all students (Merriam & Tisdell, 2015), since the goal of the study was to gain insights and develop understanding about a topic where these students were experts.

The interviewees were a cohort of students in year three on the EP in one particular school in the Stockholm region. The findings should be internally valid for the population being the third-year students on the EP in this school (Bryman, 2012), in other words, the results match the reality since they are consistent with the data collected (Merriam & Tisdell, 2015). Hopefully the reader can 'see what I see' due to the transparency as well as the amount and nature of evidence presented (Bryman, 2012).

One strength of the design was what others would criticise it for: that the researcher had deep knowledge about the students' situation. But this fact enabled me to ask the students' their opinions directly, without the need of a layer in between, for example a survey, that must be interpreted twice, first by the students and then by the researcher (Merriam & Tisdell, 2015). Therefore, the internal validity is assumed to be sufficient.

External validity

Questions about external validity, or generalisability, are more difficult. Can the findings be true within other contexts (Bryman, 2012)? If other students in the population would be asked, other obstacles might be found. Still, the findings may be seen as general for students on the EP to some degree if the sample is representative for the population. This study does not provide a thorough investigation about either the sample or the population. Although, there is some information about students on the EP in general, that may be useful to determine a certain level of representativeness. Typically, students on the EP consist of equal parts girls and boys (Skolverket, n.d.c) and 96% of those who applied for the EP were also qualified, which was the highest rate of qualified applicants at any national programme, according to Skolverket (Sökande och antagna till gymnasieskolan 2021/2022, 2021) In turn, the students that to the largest proportion were qualified for their first-hand choice were those who were born in Sweden with at least one parent born in Sweden and those whose parents had higher education themselves (Sökande och antagna till gymnasieskolan 2021/2022, 2021). Furthermore, the students applying for the EP should have been allured by the characteristic subjects on the programme, which also tell us something about a typical student on the EP. In sum, such a 'typical' student on the EP is interested in economy and business, has grades from compulsory school that were good enough for acceptance and has parents who are well educated or born in Sweden. This is also a description of the typical participant in my study, as being a student on the EP on this particular school. Does this make it reasonable to assume that all students on the EP experience the same obstacles, or will the result be substantially different due to other factors, such as geographical or socioeconomic ones? Of course, there is no way to be certain of this.

The confirmability of the study was also a concern. I tried hard not to allow my own values to intrude (Bryman, 2012), neither in the interview situation, nor in the analysis. Instead, the presumed obstacles were put aside, and I paid great attention to look for unexpected ones in order to stay objective. Nevertheless, there are problems of generalisation that cannot be denied, as mentioned above. On the other hand, there is also a danger when results are being overly generalised, due to the risk of losing sight of personal experiences (King, 2012). There is a delicate act of balance between the risk of being too subjective and too general, and hopefully this study is not at risk of any of these extremes. Furthermore, it is impossible to ensure that the findings are applicable over time (Bryman, 2012), but it is important to remember that the case study design does not make such claims about generalisability, and therefore these concerns are less relevant for this study.

Another important question to ask is whether the research is relevant or not. Is it important and is it contributing to the research field? What distinctive features are presented (Bryman, 2012)? As argued earlier, this study is of importance to a lot of people. However, the aim was not to find causalities, even though this indeed was an overall interest that led to this study, but rather to describe the obstacles in order to bring new information to the research field.

Ethics

One potential ethical problem of importance was: What if the students avoided such obstacles that had to do with the teaching in order not to criticise their teacher? Was there a conflict of interest that could hinder them (Mills et al., 2010)? Although the interviews were planned and the groups arranged to encourage students to speak freely, it was still their teacher who performed the interviews. There was a dependency hierarchy in the interview situations that cannot be denied or overseen. It is not only important to discuss the researcher's objectivity, but also the students' ditto. Could the participants really answer the question freely with their teacher as researcher? The culture within an organisation (Bryman, 2012) such as a school, very much influences how the different actors can and will perform. There is a risk that the students prevented themselves from mentioning obstacles that they thought had to do with the teaching - or the teacher - because they were in a dependency relationship to me as their teacher. This was also of concern for the quality of the study.

On the other hand, knowing the researcher could be important to encourage students' conversations (Bryman, 2012). Also, the reversed implication seemed accurate, so that knowing the students made a novice researcher better equipped to conduct the interviews in a purposeful and sensitive way.

All participants gave their written consent (see Appendix) according to what is seen as good research practice (see for example Mills et al., 2010; Vetenskapsrådet, 2017). The students were also informed orally when the project was presented to them and at the start of each interview, that they had the right to leave the project and withdraw data at any time without giving any reason for it. They were also guaranteed confidentiality, as to what was being said in the interviews and how the data would be treated (Bryman, 2012). All students were anonymised, through fictitious names, and the two classes were not disclosed to ensure that the students stayed anonymous.

The interviews took place in classrooms in school, during times when students did not have lessons, to ensure that the participation was completely voluntary. The students were sitting side by side by at a desk, in an arc shape, facing me and the laptop where the interviews were filmed and at the same time allowing them to see each other well. The idea with this spatial setting was that the students would form a group within which their conversations were to take place, without me being a central part. In the pilot interview, we were all sitting together in a circle around the table, which I believe made my presence more dominating. To enable filming the interviews, a half circle positioning was a practical choice as well.

First level of analysis

In this chapter the results and the first step of the analysis are presented. The constant comparison procedure (see for example Cohen, et al., 2018; Creswell, 2009; Timonen et al., 2018) for analysing the interviews resulted in 19 different codes, each representing a unique obstacle. The results from this iterative process of open coding are presented in Table 5, in descending order, starting with the code that was uttered by the largest number of students.

Table 5. *The codes, their frequencies and relative frequencies. (Note the differences.)*

	Code	**Number of utterances**	**% of utterances (268)**	**Number of students**	**% of students (62)**
1	new content	36	13%	30	48%
2	more difficult	33	12%	29	47%
3	more work needed	24	9%	22	35%
4	new tests	18	7%	18	29%
5	problems prioritising	25	9%	17	27%
6	online school	20	7%	17	27%
7	faster pace	19	7%	17	27%
8	motivation	14	5%	12	19%
9	tougher second year	13	5%	11	18%
10	difficult to get help	13	5%	10	16%
11	flipped classroom	10	4%	10	16%
12	more time for lessons needed	9	3%	6	10%
13	stressful	8	3%	6	10%
14	digital book	5	2%	5	8%
15	too much instruction	5	2%	5	8%
16	tasks on tests not like tasks in book	5	2%	5	8%
17	different digital tools to use (NOK, KM, GeoGebra)	4	1%	4	6%
18	don't like maths	4	1%	4	6%
19	noisy	3	1%	2	3%

Codes

In the following paragraphs, the thirteen most occurring codes will be given as thick descriptions (Stake, 2010) as possible to present the students' different views of the obstacles that they experienced. The voices of the students were crucial for understanding the obstacles' characters and the meaning that they had in the everyday life (Kvale & Brinkmann, 2009). The six codes that were uttered by as few as two to five students, codes number 14-19 in Table 5, will not be described. These codes were also quite well defined by their labels.

1. New content

Nearly every second student (48%) described the new content in Ma2b as an obstacle. This was revealed through the different ways that students explained how unfamiliar the content in the course was to them. Thomas said ”There was a lot of new content in the 2b course, compared to the first year, where there was repetition” while Steven explained how he believed that each new year was a rehearsal of the previous one, until Ma2b, when saying,

> *In the first year there was a lot of repetition of what you did in ninth grade. In year two there is completely new stuff. You are prepared for repetition of year one, as usual. In ninth grade there is repetition of eighth grade. And then you get to year two and everything is completely new.*

Some students exemplified what was new to them, such as certain procedures, as Michelle did when she said, "A lot was new and several new operations, for example the formula for quadratic equations." Amanda, on the other hand, believed that new concepts were the difference. She said, "In the first year there was a lot of repetition from ninth grade. However, in the second year there were many new concepts."

Others linked this obstacle with problems they had remembering what they were supposed to learn. George commented that "In the first year you could remember how to do things, but in the second course it was completely new." Stephanie also recognised a need for maintaining knowledge from Ma1b at the same time as learning the new content, saying, "I agree, you recognised almost everything from ninth grade, and then there were a lot of new things to take in and at the same time maintain the things from first year."

Among the many students who believed the new content to be an obstacle, there were quite a few that in different words put emphasis on the quantity or completeness of the new content, as seen in this groups' short discussion:

> *Charles: There were a lot of new things, there was a lot of repetition in year one.*
> *Daniel: Yes, in year two there were completely new things that you had not done before.*
> *Matthew: And much more as well.*

To conclude, new content was identified as an obstacle as it emerged from the fact that almost half of all students experienced the mathematical content in Ma2b as being unfamiliar to them.

2. More difficult

Almost half of the students (47%) spoke, in various ways, about Ma2b being more difficult than Ma1b. For some, these difficulties were unspecified, while others offered some elaboration on the problem. From the perspective of unspecified difficulties, John commented that, "[Y]es, we do new things every time that are difficult for real". In similar vein, Eric commented only that "It was a more difficult course", while Kimberly was almost as vague when she added that the increase in difficulty actually led to a need for her to put more effort into her study. She said, "It gets harder in each course and then I have to spend more time learning." Others offered slightly more detail when describing how moving between the two courses created a great leap or a huge step for them. This was exemplified in the exchange between Elizabeth and Linda, who said

Elizabeth: Year two was a lot harder than year one, it was sort of new.
Linda: Year one was kind of a repetition of ninth grade.
Elizabeth: Exactly, and when we came to year two it was…
Linda: … a big jump.

Similarly, Deborah mentioned the step between the two courses as being connected to the obstacle with the new content, saying, "It was a big step between course one and two. Course one was easier because it was repetition. Course two contained a lot of new stuff" while Jeffrey added that "The difference between year one and two was that year one had a lot of repetition while a lot in year two was new, and you were not prepared for that step."

That being said, a few students specified the content that they struggled with, as seen in Sarah's comments about quadratic functions and equations. She said, "I thought it was much harder. Quadratic functions and such", while Rebecca added, with respect to the latter, that "New things, like the formula for quadratic equations which we had never done before. A higher level and a lot of new things".

In sum, approximately half of all students, with varying degrees of detail, indicated that the shift from Ma1b to Ma2b created unexpected difficulties and a leap in content that was larger than they had expected.

3. More work needed

More than a third of the students (35%) experienced an obstacle as they had to do more work on mathematics outside school than before. Some of the students related this obstacle to the course being more difficult, as David, who said that "It is harder now and then you must put in more time yourself. And I never manage to finish what we are assigned to do during class." Dorothy described a similar view but added that this was partly due to the online teaching. She said, "And everything was a lot harder during distance education and you needed more time to understand before you could move on to the next thing."

There were also those that did not find the course more difficult, but recognized problems finding time to work on the mathematics, as Kevin, who stated that "I did not think it was harder, I needed to put in more time. The problem was to find the time to do maths."

Among students that did not experience the course as more difficult, there were those who explained why they came to that conclusion, and also how important time put into their studies was for their understanding, as seen in this conversation between Mary and Patricia:

Mary: I did not really think that course two was that much harder than course one, once you put in the time, once you got it I did not find it harder.
Patricia: Maths is not fun if you do not understand. So, you have to put in time to understand or else you can never move forward.

To summarise, a third of all students found an obstacle in having to work more on mathematics for different reasons.

4. New tests

This particular year, the mathematics department decided to have cumulative tests on four occasions evenly distributed across the school year in each course. In each new test, content from all earlier sections were tested as well as the recent sections. Previously, well limited tests had been given after each section of the course.

About 29% of the students expressed that *new tests* were obstacles for them. Some students thought it was more difficult to study for the cumulative tests. This was exemplified by Christopher, who said,

> *Yes, I think that when you have taken a test you are done with that part, and I am best at studying before a test, sort of, when there is a bit of stress, I find it difficult planning to study everything beforehand, which means that when there is new content it is hard to recall it later.*

The students did not always agree. Although some students experienced the new tests as an obstacle, they were clear about the benefits that they gained, as shown in this group's conversation:

> *Susan: The test setup in year two was not the same as in year one, there was a big difference.*
> *Interviewer: Did that create an obstacle for learning?*
> *Susan: You had more studying to do, you could not just focus and then let it go, now I have taken the test and I can let it go, just the formula for quadratic equations, now it was everything, you know, and that is probably good, but…*
> *Richard: There were a lot of things you had to study at the end, then there were all the old and the new stuff.*
> *[...]*
> *Susan: In fact, the way we do it now is good, because you repeat, but at the moment, it was not that nice.*
> *Joseph: I think it was nice to have it that way. Then you had done the parts we had at the beginning, which recurred often, so that you already knew how to do it and therefore you could go through it quickly.*
> *Susan: Not if you found it difficult.*

Another way in which the new tests were considered to be of hindrance, was shown by the explanation given by Gary, who experienced problems recognising his own knowledge, saying,

> *I thought it was difficult that earlier stuff was included in the next test, it was hard for me to know what to study, like, what I know and what I need to practice. What are my weaknesses in this area, it is so big, there are so many things to know and then I sort of messed around, I am lost, I do not know what I need before the test. I struggled with that. The whole course test was a bit better, then I could study old national tests and repeat everything, but it was very hart to study for the three-quarter-test.*

In sum, 29% of the students argued that the new, cumulative tests were problematic for them.

5. Problems prioritising

More than a quarter of the students (27%) faced obstacles learning mathematics due to how they prioritised their studies. This manifested itself differently, but two major problems concerning prioritisation were identified. Firstly, some students experienced difficulties prioritising their course work in general. Secondly, others stated that they consciously prioritised other subjects over the mathematics course.

The first group of students explained that problems with prioritising occurred as a consequence of lack of discipline. This can be seen in a conversation between two students, where David described his problems with prioritising in relation to other obstacles, such as the increased difficulty of the course content and having to spend more time on the course work. William, on the other hand, focused on his need for coaching or sharp deadlines to stay disciplined and prioritise mathematics:

> *David: It is mainly up to oneself, you may be self-disciplined and put in the hours needed, which in my case I know I did not, so it really is… it is up to oneself. It is harder now and therefore you will have to put in the hours yourself. And I never manage to keep up with what we are supposed to do in class.*

William: It is up to oneself, but it works well when you explain on the board and such, like when you write down problems and then we are forced to work… so then I at least follow and try to understand and then I understand quickly sort of. But when I do it by myself… I need someone to push me a bit, then it works, or have something that stresses, like at the end of the year, otherwise I am bad at self-discipline.

The second group of students actively chose to prioritise other subjects over mathematics. They either experienced a need to work more on tasks in other subjects or chose to focus on the subjects that they found more interesting, fun or easy. As seen in the following conversation, the first student, Amanda, explained that she prioritised other subjects due to the workload in these courses, while her friend, Carol, prioritised work in subjects she enjoyed better. They said,

Amanda: I put it off, partly because there was a lot of work in other subjects and then you did not prioritise it. There are no submissions in maths, as in other subjects, but rather tests and then you just study for the tests.
Carol: I put it off quite a lot and I thought that other subjects were more enjoyable as I understood them better so then I studied them more.

In some of these cases, students' prioritisation was affected by how assessments and exams were organised in different subjects. For example, Dorothy stated that studying mathematics was less urgent because of deadlines in other courses. Following this idea, Jacob said that he intended to manage the mathematics course by passing a test later on, an approach that was impossible to have in other subjects. And, finally, Nicholas concluded that he had to take things in order. They said:

Dorothy: It is easier to not prioritise maths, because there you have the tests you have, while there are other assignments to submit in other courses and studying for the test was not as prioritised.
Jacob: In maths you could compensate at upcoming tests, but in other courses there could be a knowledge requirement that is only tested once, and you had to make it and in maths you could perhaps show your skills later.
Nicholas: You look at the examination schedule and then you must do things in order.

Even students who acknowledged the need for regular work on mathematics experienced similar problems with prioritising, as Jessica, who said: "It is easy to not prioritise when you have a social science essay due next week, for example, then that is prioritised, but in maths you have to maintain it every day, drill."

In sum, 27% of the students experienced obstacles as a result of their prioritisation. In some cases, this was a result of their personal discipline, while some students consciously prioritised other subjects and, therefore, postponed or disregarded their work in mathematics.

6. Online school

This obstacle appeared unexpectedly during the Covid 19 pandemic as schools were forced to function entirely or partly online. All upper secondary schools in Sweden shifted to online teaching during the three final months of the school year, that is, from March to June 2020. More than a quarter of the students (27%) found this problematic and offered various assertions about this. Some students were quite unspecified in their descriptions, such as William, who simply stated that "We should completely skip online maths, it just does not work." Another vague opinion was given by Nicholas, who said that "In my opinion it is not possible to study maths from a distance. It became a completely different thing."

Other students tried to explain why it was difficult to learn online and what they missed about attending school in real life, as John described:

I thought it was difficult to get help when you sat at home, you became very independent, you could not get help from friends either. [...] I usually do that when we are here, then you can sit down with people and so all can sit together. I did that just before online school, then the maths course went really well. After that it just went downhill.

The situation with online school also seemed to increase other possible obstacles for some students, such as being independent and having more responsibility for one's studies. Gary explained how online teaching led to problems, as he said

At first it went bad, it was like F, F, F and then I thought I will have to get going and study more and I did that in school before the pandemic, and when we started online school I just sit there with my gaming computer next to me like, okay, solve three problems and I almost fall asleep, so then I could either lay down in bed or play games, so it was hard in general to study from home. [...] When we had class in school you were great. Even if I did not use the tools you give us it was fine, I thought that in year one too, but with online school it gets difficult for you too, like, you cannot see if I am playing games. You cannot really ask me every five minutes; Gary, what are you doing now?

Some students were convinced that online school was a problem, but at the same time believed they were able to work more in more focused ways, without being disturbed or interrupted, at home. This conversation showed this ambiguity:

Christopher: Distance learning. No one has ever had that before which made it problematic. It was new to everyone, getting help was a bit harder, and I struggle with accepting help anyways, I have hardly ever asked you for help, but when you work from home it is harder to work on maths problems than it is in school.
Daniel: I agree.
Christopher: You have other surroundings, you have the bed next to you, so when you get to a difficult maths problem it gets hard to continue.
Matthew: That is true, it is hard to get help, but distance learning works pretty well for me, it is nice and quiet, and no one is disturbing.
[...]
Margaret: When you are at home you sometimes work well, but some days were worse and then it was difficult to be motivated to sit at the desk in your room and work on maths. Sometimes it is hard to get the work done during lessons in school with a lot of friends around, then it is easier to work at home.
Daniel: Yes, you got more peace, but it was not easy to ask for help.

In summary, online school was identified as an obstacle to over one fourth of the students, as they mentioned this explicitly in the interviews.

7. Faster pace

About a quarter of the students (27%) said that faster pace was an obstacle for learning. They also presented a great variety to how they experienced it, although the major theme, in common for all, was that they had difficulties keeping up with the pace. Ryan commented that, “The biggest problem is that it is moving too fast, you do not have time to focus on one thing, it is always two things.” To some, this affected the understanding or how fun they experienced mathematics, as Melissa described, “And it went very fast in maths, and when you grasp something, it feels like it is already many steps ahead, so then you do not keep up. [...] When it moves ahead that fast it is not as fun.”

Following a similar track, Barbara and Jennifer added that

> *Barbara: It is hard to work at your own pace.*
> *Jennifer: It is like you do not understand why you do what you do, but just do it to catch up.*

Others expressed how the unexpected pace of new material caused confusion. For example, Steven said:

> *Yes, the pace was very high. You are not used to it. Everything is very fast. It is a new thing lesson after lesson, first 1.1 then 1.2 and 1.3. You do not have time to learn 1.1 before you move on to 1.2 and then you think about both at the same time and more and more builds up and you mix everything up because you have not learned everything correctly.*

Elizabeth explained how learning deteriorated due to the pace. She was very clear about the need for repetition for remembering, and said:

> *We would have needed a week to learn one section, because then you remember, it sticks to your memory longer, rather than learning four different sections during two lessons in one week, like, that is just… it feels like you rush through everything and then you do not remember, but you need to repeat, repeat, repeat, which you should do anyways, but it would be easier if you have the foundations.*

Some students did not believe that the actual pace was higher than before, but since the content was new to them, the pace appeared to be higher. These two obstacles were interleaved, which was explained by Jessica, who said,

> *They are related to each other. New content requires more time. So, the pace might be the same, but the content had not managed to stick until the next lesson, so then it felt like you fell behind, because you were not sure of what you did last week and that caused stress. The pace might not have been higher, but it felt that way.*

To summarise, a quarter of the students explicitly mentioned how fast pace influenced their learning negatively.

8. Motivation

About one fifth of the students (19%) explicitly spoke about problems with motivation as an obstacle when learning mathematics. For some, their motivation to study had decreased in general during the second year, while others experienced a lack of motivation in mathematics specifically. Regarding a general lack of motivation, Thomas said that "Sadly, I had no motivation in year two, to be honest, then, at the end… yeah… then I got help from you as well." Later in this group's conversation, Susan and Thomas explained how running into specific problems in mathematics resulted in a lack of motivation, as they commented:

> *Susan: At the same time, if you do not get it you skip and think 'I will ask Monica on Thursday' and then we have the weekly test, and we have this, and then I will not have the time to ask, and it just piles up…*
> *Thomas: … that is when you lose motivation.*

Other students had similar experiences of not being successful in relation to a lack of motivation. Daniel said that "You get a bit unmotivated when you cannot solve the first problem, sort of." and Lisa, who said, "When you cannot work it out and you do not understand very quickly, you will not become motivated. You sit there with a problem and give up when you do not get anywhere, you check the solution and move on."

Some students experienced problems with motivation during online school, as seen in Charles's comments, as he was saying, "Sometimes you worked well, when you were at home, but some days were worse and then it was hard to be motivated to sit at the desk in your room and study maths."

Among the students that had a lack of motivation in mathematics, there were those that explained this in combination with their feelings towards mathematics, as Kevin, who said, "I had a hard time finding motivation, I am not a maths person, you know, I did not find it enjoyable".

Furthermore, some students experienced several of these variations; their motivation was affected by online school, not putting in the time needed and personal preferences, as shown in this conversation with Jeffrey:

> *Jeffrey: I thought, not about maths itself, that the motivation to have online school… or it made me fall behind to some extent anyways, I did not put in the time needed.*
> *Interviewer: Was that specific for mathematics?*
> *Jeffrey: No, in general, then of course there were other subjects I found more amusing, where I still kept the same pace, the same motivation, but in school in general.*

Similarly, Nicholas expressed how the workload combined with online school led to problems with motivation and postponing work. He said,

> *There were so many things to do during the last months when all the grades were about to be set, then there were a lot of hand-in assignments. And with distance learning, I could not do it, I was not motivated. Everything was just postponed, and it created a big knot in my stomach.*

In sum, nearly one out of five students explicitly mentioned a lack of motivation as an obstacle for learning, in various ways and combined with other hurdles.

9. Second year tougher

Nearly one fifth of the students (18%) were experiencing their second year in upper secondary school as tougher in general, compared to their first year. This led to problems in mathematics, as Gary described when saying that "The hardest part for me was that I had so many things going on, like, year two in general was a tough year and focus had to be on so many things, so I did not have the energy, patience and time to put into maths."

Similarly, some students expressed that they had more work to do in general and a lot of new content in other courses, as shown in the exchange between Thomas and Susan:

> *Thomas: And we had a lot of other things as well.*
> *Susan: Yes, it is not just maths in school.*
> *[...]*
> *Thomas: Generally speaking, there are a lot of new things in year two, in other subjects as well. There is a lot of studying in general.*

Other students added other aspects to their descriptions of this obstacle, such as prioritising and pace. Steven and Mark said that,

> *Steven: And you have other courses as well, with a whole bunch of tests and stuff and it ends up being too much to study and then you have to prioritise. [...] There was one test a week in year two and a faster pace in all subjects.*
> *Mark: Yes, even subjects you usually thought were easy.*

As seen in these examples, the second year was considered tougher in general, which roughly one fifth of all students expressed.

10. Difficult to get help

This code was identified among the students (16%) that were hindered in their learning process because there were too many students in need of the teacher's help at the same time. This made it difficult for them to get help when they needed it, and some students concluded that one teacher was not enough. The conversation between David and Patricia showed this, as they said

> *David: Sometimes it was hard to get help, when you got stuck on a problem and there were like five others before you, so you completely lost your motivation and then you kind of watched YouTube or did something else and then… the lesson is over.*
> *Patricia: I can agree on that, that one teacher is not enough, it does not work, maybe it worked in year one, because it was mostly repetition, but when it moves ahead so fast you should really learn, you start with something new one lesson and then it is done after that lesson, and you have not gotten the help, it did not work, you know. And if you get stuck, yeah, I do not know if there is something special about our maths textbook, but when I got stuck I looked at a solution and I did not understand what the right answer was, but it was just to move on to the next problem, to not fall behind and then you sit like a big question mark during the test, you have seen that kind of problem, but… you do not know how to solve it, because you did not get the help.*

Some students compared the problem with having one teacher to the improvement they experienced during a period of five weeks when two students from Stockholm's University were doing their teacher training internship at the school. Betty, Sandra and Margaret said that

> *Betty: And I thought that only having you as a teacher was a small obstacle, you could really have needed two teachers.*
> *Sandra: That is true. Since you are the only teacher there is not enough time for everyone to get help and if someone needs extra help you sit down with them for quite some time, so that takes time away from everyone else who actually also needs help.*
> *Margaret: It was really smooth when we had the two pre-service teachers. Then, all could get help regardless, and you also had time to help others.*

In a similar way, Paul elucidated that,

> *Since it was new it became harder and because you were the only teacher it was harder for us to get help, but when we had the pre-service teachers, I got more help and could learn more. I could really understand what I was doing. In year one I already had previous knowledge from ninth grade, so therefore not as much help was needed to learn.*

A few students experienced difficulty getting help during online school, as seen in comments given by Daniel, who said that "Yes, you got more peace, but it was not easy to ask for help." and Paul, who said that "Online school was harder, for example to get help during lessons."

To summarise, there were 16% of the students who explicitly said that they found it difficult to get help or that there was a need for two teachers in the course.

11. Flipped classroom

Ten students (16%) experienced that the teaching idea called 'flipped classroom' did not work out well for them. In short, flipped classroom is a teaching method where the main idea is to flip the location of where the instruction and the work on tasks are done, that is, swap what is being done in school and what is being done at home (Weinberg & Thomas, 2018). In a non-flipped, 'normal', classroom, some time is spent on lectures and worked examples and some time is spent on practice. The students often have to finish the tasks at home. In a flipped classroom, the students watch video lectures including instruction and worked examples before class, at home, to have more time in class for practicing, with the teacher being available for helping and leading activities. The classes in this study had agreed on the flipped classroom arrangement after discussing and voting at the beginning of the course, but it did not work out as planned, and the model was largely abandoned. The interviews revealed that students did not watch the videos for various reasons. Some had problems remembering to watch them, as seen in this conversation, where Michelle, Donna and Emily commented this saying,

Michelle: Yes, remembering to watch the videos.
Donna: Yes, it is easy to forget, you have all the other courses and assignments, so you have to set an alarm, sort of.
Emily: I had that routine, the night before, and it worked very well.

Some students preferred teacher led instructions in class while other students started using the videos halfway into the course, as seen in the conversation between Nancy and Kevin, who said

Nancy: We have the videos to watch. Having videos is clever, but I think your instructions are good, then it is easier to stay focused when we are here in school, and you can ask questions when you do not understand. I am not a big fan of videos and I have not been the best at watching the videos either.
Kevin: I did not watch the videos at the beginning. But when the second term began, I really started to watch every video over and over again and it helped a lot. I watched the videos and then I worked a lot with all the parts in Kunskapsmatrisen. That is how I made it.

This obstacle revealed disagreements in the groups, as seen in the discussion below, where Paul was critical to the method while Jessica and Andrew recognised benefits. This is what they said:

Paul: Maybe if you would have had more instructions during the lessons, I watched the video at home, but I think it would have helped to hear it during the lesson as well. I prefer going to school and getting everything I need, sort of, then I can focus on other things later. I like it more when the teacher offers explanations in school, rather than the videos. They are good as well, but…
Jessica: … but then you cannot get help with problems…
Andrew: … and then there is less time to work.
Paul: Yeah, that is true, but in my experience, it is better that you explain everything during the lessons. That works the best in my schedule, when I get home, I want to do other things, I want to work out not do maths.
Jessica: It is easy to not make it a priority, but it is your own responsibility. If you want a good grade you might have to watch the videos and be prepared for the lessons, that is how I reasoned.

In sum, *flipped classroom* was seen as an obstacle by 16% of the students who talked about having problems remembering to watch videos before class, or that they preferred teacher-led explanations.

12. More time for lessons needed

Six students (10%) believed a lack of time for mathematics in school to be an obstacle. Each mathematics course was given two lessons every week, about 75-80 minutes each. These students expressed a need for more lessons or longer lessons, and in various ways, they explained how this led to problems. For example, Elizabeth, who talked about what difference more time for lessons would have made for her learning, said,

Time was an issue. It would be better if we would have had twice as much maths. Then you could have led a proper instruction, like a rundown of the basics, plus something a bit harder for everyone, and then I could have solved half of the problems in one lesson and the rest during the next lesson. And I could have rehearsed more before tests.

In a similar vein, Lisa explained how she would benefit from more time on mathematics in relation to how she experienced that she, under the given circumstances, did not have time to do all the work that she wanted. She made a clear connection to the pace, when saying, *It feels like you need more maths, like two hours each lesson, because then you can give a proper explanation and I have time to work on it. Now it is like you give an explanation and then I do not have time to do as much as I would have wanted. And the next lesson there is a new chapter, and I have to leave it behind and tackle it later.*

Some students acknowledged the need for studying mathematics at home, but also thought that the limited time spent on mathematics in school was an obstacle, as is shown in this conversation between Ryan and Jeffrey, who said,

Ryan: Personally, I think there is not enough time to learn during lessons, there is nothing to do about it, but you have one lesson to learn a new section, that is not very easy. More time would be nicer.
Jeffrey: Mathematics in general is time consuming. There is a lot you have to do at home, you should be prepared for the lessons, and you should read up on things, but you need more time in school with the teacher, that would make it easier for many students.
Ryan: It is always the same people who want help all the time and then there is not a lot of time for everyone else.
[...]
Jeffrey: I do not think it is the teacher who should be questioned, but rather the system. You should have extra maths classes or split the class into two, maths should get more resources in the school system.

Donna also talked about how she dealt with this problem, when choosing not to listen to all of the teacher-led part of the lesson. She explained that,

Sometimes I made a choice whether I would need the teacher-led instruction or if I would get more out of solving a few problems to catch up, listening a bit, but… I get that you need explanations and such, you could in fact need more lesson time in maths to manage, but you just have to use your spare time.

In sum, 10% of the students explicitly said that they had problems learning the course content because of the time constraints on the number or lengths of the lessons.

13. Stressful

This obstacle was identified among the 10% of the students who experienced either the mathematics course or their entire school situation as stressful, and explicitly mentioned this.

Some students, as Barbara, had problems finding time to study the new material for the small, weekly tests, and therefore experienced stress. She said that "It was stressful, the new elements we started with, so you did not really have time to study for the weekly test." Later in the conversation, she explained further how this had to do with the pace, when saying that, "I found the weekly tests a bit stressful, because if you had any problems with the last thing you might want to fully focus on that instead of getting a new weekly test on the new chapter. It is difficult to work at your own pace." Adding to this, Jennifer, said that "And even if you study at home, you still get stressed."

Again, students show that the obstacles were interleaved, as Sandra shows in her comment about the pace and the stressfulness: "I thought the pace was high in the course if you did not dedicate it all your time. I feel like I would not have managed the course if I had not prioritised maths, because it is so stressful, you have to study a little every day."

Thus, stressfulness was identified as an obstacle among the 10% of the students who explicitly mentioned it as such.

Second level of analysis

In the first step of the analysis, the codes were found and presented. Here, the second step of the analysis, where the codes were grouped into categories, will be presented. Each category will have its own section in which the categorisation will be explained and motivated.

Categories

To make it possible to get an overview of the results from the open coding, a second level of coding was necessary. Therefore, a process of axial coding (Merriam et al., 2015; Mills et al., 2010) of the nineteen different codes were undertaken. As discovered in the interviews, and mentioned earlier, some codes seemed to be naturally interleaved. This can be seen in Joseph's comment, where he showed how the obstacles new content and faster pace were interleaved, when saying: "The pace was the same as in the first year, but there was much repetition then, now a lot was new, so you kind of did not have time to take it in."

Working through the codes, I hypothesised connections between them, based on the knowledge I had gained when considering the ways in which the students' conversations had covered different groups of codes. Each code's possible connection to the rest of the codes was scrutinised, by examining the transcripts from the interviews and the memos (Mills et al., 2010; Timonen et al., 2018) I had created throughout the coding process, before a pair or a group of codes was established. Altogether, this work led to identifying five distinct categories of obstacles: *advanced mathematics, managing workload, novel teaching, emotion* and *assessment*. Each category included two to six codes, as seen in Table 6.

Table 6. *Categories and codes and proportions of students, utterances and groups*

Category	Advanced mathematics	Managing workload	Emotion	Novel teaching	Assessment
Code ***(% of students)***	new content *(48%)*	more work needed *(35%)*	motivation *(19%)*	online school *(27%)*	new tests *(29%)*
	more difficult *(47%)*	problems prioritising *(27%)*	difficult to get help *(16%)*	flipped classroom *(16%)*	tasks on tests not like tasks in book *(8%)*
	faster pace *(27%)*	tougher second year *(18%)*	stressful *(10%)*	digital book *(8%)*	
		more time for lessons needed *(10%)*	too much instruction *(8%)*	different digital tools to use *(6%)*	
			don't like maths *(6%)*		
			noisy *(3%)*		
% of students	**84%**	**60%**	**34%**	**45%**	**19%**
% of utterances	**33%**	**24%**	**17%**	**16%**	**10%**
% of groups	**100%**	**94%**	**75%**	**94%**	**69%**

Advanced mathematics

This category included the codes *more difficult*, *new content* and *faster pace*, all of which are having to do with the mathematics becoming more advanced in the second course. *More difficult* and *new content* are clearly connected to the progression within the courses since it is natural that a new course also contains novel and more advanced content compared to previous courses. The code *faster pace* is connected to the other two codes, *more difficult* and *new content*. The core content in the curricula for the courses Ma1b and Ma2b must be covered during the lessons at hand, and if the content is distributed on the amount of time, which is 100 hours in each course, the pace will be set. One might argue that there is no difference in the pace, or even say that Ma1b runs at a faster pace since it covers a larger range of content. This is of course a crude way to try to measure the pace, which does not consider the fact that most of the content in Ma1b was familiar to the students, while the opposite was true for the content in Ma2b. Some of the students in this study experienced a faster pace in the second course, in relation to the unfamiliarity of the content, the *new content*. It is also reasonable to argue that the students who thought that the content was more difficult also had problems with the pace. Thus, the obstacle *faster pace* was also placed under the category *advanced mathematics*.

Managing workload

Four of the obstacles, *more work needed, more time for maths in school needed, tougher second year* and *problems prioritising*, are included in this category through slightly different aspects of how the workload is managed by the students. The codes *more work needed* and *more time for maths in school needed*, are clearly concerning workload. These students argued that the fact that they would need to spend more time on mathematics, regardless of if they needed to study more at home or if the lessons would need to be longer, was problematic. For students who spent their entire life in school, a sudden, unexpected or unmotivated change in workload was recognised as a very real obstacle for their learning. Especially if they had not had that experience in school until then.

This category also contained the code *tougher second year* which seemed to be connected to the previous two codes. It was not likely that all students would find ways of balancing the need for more work or time spent on mathematics with less work in other subjects or areas of their personal lives, if they believed that the second school year became tougher in general.

Also, the code *problems prioritising*, was dealing with aspects of workload, since you could argue that the increase in workload was forcing students to prioritise harder or more carefully. Some students explicitly made it clear that they had no other option than to prioritise other subjects. And the students that had problems with personal responsibility, or planning their work in general, fell into trouble with difficulty in prioritising. Thus, they could not manage their workload.

Notice that codes in the workload-category probably had connections to codes in the advanced mathematics-category as well, as one might argue that a *more difficult* content and a *faster pace* would lead to a greater workload, unless some ways to compensate for this was possible in other areas. This will not be the first time that the problem of separating categories occurs in this study.

Emotion

Six of the codes were categorised into the group that dealt with emotions in different aspects: *stressful, motivation, too much instruction, noisy, difficult to get help* and *don't like maths*. This was a wide variety of codes with a common core in the fact that they all dealt with aspects of obstacles concerning the student's beliefs, such as feelings, values, opinions, biases and attitudes. Thus, they were all emotion-driven obstacles. Experiences of stressfulness, lack of motivation or a dislike towards mathematics, were certainly stirring up troublesome emotions within the students. Also, those students that thought that there was too much instruction, noisy or difficult to get help during the lessons, would have experienced negative emotions due to this, not least because these were aspects that lay out of reach of the students' own agency. To these students' experience, they could not influence these obstacles, but they were still affected by them.

Novel teaching

Four of the codes, *digital book, online school, flipped classroom* and *different digital tools to use*, were all aspects of how students were expressing novelty towards some new aspects of the teaching. If students' views of a typical mathematics lesson (Andrews & Larson, 2017) are in conflict with the actual teaching, for example through new, unfamiliar or unconventional methods and models, this may be considered as obstacles to some of them. The didactical contract will be broken and in need of renegotiation (Jankvist, 2015; Jankvist, et al., 2016). Some students were not quite comfortable with the digital book (Alfredson et al., 2017), the other digital tools (Wallin et al., 2017) at use or the flipped classroom-model, although all of this had been in use in the previous course. They were still novices to some extent. Some students explicitly expressed their reluctance to learn how to use digital tools in mathematics, although this was a part of the curriculum (Jankvist et al., 2016; Skolverket, 2012, 2013).

What definitely was new, was the pandemic that forced the schools to teach online for several months, from March to the end of the school year in June. All of us were novices with respect to online teaching, which made it easy to place this obstacle in the novel teaching-category.

Assessment

The codes *new tests* and *tasks on tests not like tasks in book* were related to assessment. The students in this group signalled that they fell into trouble with the cumulative way the tests were organised or that they had problems with the questions in the tests, that were not looking like the tasks in the textbook. Individually, or together, these two obstacles affected these students' results on the tests negatively, and thus, the assessment, as well.

Major findings

The purpose of this section is to present the major findings, or evidence (Merriam & Tisdell, 2015), derived from the two levels of analysis. The obstacles and categories can form bases for building hypotheses for understanding what students see as obstacles, which was the purpose of the study. I will end this chapter with a brief summary of the major findings.

Main obstacles

Table 7, below, shows a fusion of the results from the first level of analysis, that rendered the codes, and the second level, that lead to grouping the codes into categories. The headings show the categories, and the columns show the codes included in each category, in descending order according to the relative frequencies of the number of students uttering each code. Table 7 is the same as Table 6, but all codes uttered by at least a quarter of all students, more precisely 27% - 48%, are coloured to highlight the seven obstacles that were most common and to what categories these belong. An excerpt from Table 7 show that these seven obstacles form a top-five-obstacle-list:

1. *new content* (48%)
2. *more difficult* (47%)
3. *more work needed* (35%)
4. *new tests* (29%)
5. *faster pace*, *online school* and *problems prioritising* (27%)

When planning this project, some of these obstacles were among those that I had foreseen, such as *more difficult* and *faster pace*, while others were unexpected, such as more *work needed* and *problems prioritising*. In short, these findings show that the main obstacles were *new content*, *more difficult* and *more work needed*.

Main categories

The tree rows at the bottom of Table 7 show some interesting proportions derived from the results. Depending on how different parts of the data, or 'proportions', are compared to different entities, or 'wholes', the results can be viewed from various perspectives. These three comparisons can be seen as different ways to understand the spread and weight of each category, as the results concerning the categories are presented from three angles:

- ***Proportion of students***. The third row from the bottom shows the proportion of the number of students that uttered an obstacle within each category (of the 62 students). Obstacles in the category advanced mathematics were uttered by 84% of the students, followed by the category managing workload uttered by 60% of the students and novel teaching uttered by 45% of the students. It is important to notice that some students uttered a certain obstacle more than once. Here, however, only one of these utterances has been counted. This result points out how common each category is among the students.

- ***Proportion of utterances***. The second row from the bottom shows each category's proportion of the total number of utterances (of the total of 268 utterances). Obstacles in the category *advanced workload* yields the highest frequency of the total number of utterances in the study, 33%, followed by *managing workload*, 24%, and *emotion*, 17%. Notice that each obstacle was counted each time it was uttered, and the sum was compared to the total number of utterances. This informs us of what categories students mention the most in their conversations.

- ***Proportion of groups***. The bottom row shows the proportion of the number of groups that uttered an obstacle in the category (of the total of 16 groups). All the interview groups talked about obstacles in the category *advanced mathematics*, and almost all groups, 94%, talked about obstacles in the categories *managing workload* and *novel teaching*. From this result we know to what degree different topics were covered in the group conversations.

Although these three ways of calculating proportions can be used for slightly different interpretations of the results, the category *advanced mathematics* can be seen as the most important category for two reasons. Firstly, it reached the largest proportion in all three calculations, and secondly, all obstacles in this category are included in the top-five-obstacle-list as presented above. Also, *managing workload* is in second place in all three calculations. In sum, the main categories of obstacles were *advanced mathematics* and *managing workload*.

Table 7. *Categories and codes and proportions of students, utterances and groups (same as Table 6, but coloured to highlight the codes with the highest relative frequencies)*

Category	**advanced mathematics**	**managing workload**	**emotion**	**novel teaching**	**assessment**
Code *(% of students)*	new content *(48%)*	more work needed *(35%)*	motivation *(19%)*	online school *(27%)*	new tests *(29%)*
	more difficult *(47%)*	problems prioritising *(27%)*	difficult to get help *(16%)*	flipped classroom *(16%)*	tasks on tests not like tasks in book *(8%)*
	faster pace *(27%)*	tougher second year *(18%)*	stressful *(10%)*	digital book *(8%)*	
		more time for lessons needed *(10%)*	too much instruction *(8%)*	different digital tools to use *(6%)*	
			don't like maths *(6%)*		
			noisy *(3%)*		
% of students	**84%**	**60%**	**34%**	**45%**	**19%**
% of utterances	**33%**	**24%**	**17%**	**16%**	**10%**
% of groups	**100%**	**94%**	**75%**	**94%**	**69%**

Summary

The purpose of this study was to find what obstacles students believed that they encountered when studying the course Ma2b. In order to do this an instrumental, exploratory case study was planned, where 16 group interviews were conducted. The interviews were analysed using a constant comparison process, as a first step, which resulted in 19 different codes (obstacles) being found and thoroughly described and exemplified with students' comments. As a second step in the analysis, the codes were grouped into five larger categories, through a process where all the data and memos were condensed to enable a broader picture of the findings to emerge. Finally, findings, which could function as a base for hypotheses about what specific obstacles and what categories of obstacles students on the EP may experience, were presented. The overall most tangible finding was that the category *advanced mathematics*, which included the obstacles *new content*, *more difficult* and *faster pace*, proved to hold the largest proportions of (1) the students mentioning these obstacles, (2) the utterances in total and (3) the groups discussing these obstacles.

Discussion and reflections

In this section, the outcome of the analyses with expected as well as unexpected results will be discussed. This will be structured around the five categories in relation to the areas that were presumed at the start of the project. Furthermore, concerns and limitations according to the method will be reflected upon and some implications for practice and recommendations for further research will be presented.

Categories and presumed areas

At the start of the project three *areas* were discussed wherein different obstacles might be located. The three presumed areas were: *students' affect, students' views on mathematics teaching* and *students' views on the nature of mathematics*. The presumed areas were put aside while conducting the interviews and analysing the data. After coding, describing and categorising the obstacles, a comparison with the presumed areas was made, which showed that all three areas were well covered by four of the five categories. Thus, there was one category of obstacles that was not considered in advance, an unexpected area, which is shown in Table 8. The categories connected to the areas, presumed as well as unexpected, will each be discussed, with focus on particular issues within each category.

Table 8. *An overview of presumed and unexpected areas, categories and codes.*

	Presumed areas				Unexpected area
	Students' views on the nature of mathematics	***Students' affect***	***Students' views on mathematics teaching***		
Cate-gory	**Advanced mathematics**	**Emotion**	**Novel teaching**	**Assessment**	**Managing workload**
Codes	new content, more difficult, faster pace	motivation, difficult to get help, stressful, too much instruction, don't like maths, noisy	online school, flipped classroom, digital book, different digital tools to use	new tests, tasks on tests not like tasks in book	more work needed, problems prioritising, tougher second year, more time for lessons needed

Advanced mathematics ≈ students' views on the nature of mathematics

Obstacles in the category advanced mathematics were all concerning what was going on 'within' the subject itself, such as the mathematics being difficult or the content being new, and what was merely 'ruled by' the school subject itself, such as the course running at a faster pace. Such obstacles are well connected to the nature of mathematics, its epistemology (Dossey, 1992), in the sense that they cannot be influenced by any of the actors on the 'outside', such as the students and the teacher. This resembles Jankvist's (2015) ideas of students' images about mathematics as a discipline which has certain characteristics and purposes. In this paragraph, some aspects of the obstacles within the category *advanced mathematics*, as belonging to the area called *students' views on the nature of mathematics*, will be discussed.

Advanced mathematics and orientations of views

Tossavainen et al. (2021ab) studied the relations between mathematics task performance and views about mathematics among first-year engineering students with the use of a framework by Felbrich, Müller and Blömeke (2008) for characterising beliefs about the nature of mathematics. The framework presents four different orientations,

- ***Formalism-related***: mathematics is an exact science, based on axioms and developed by deduction. Abstraction and logic are central for thinking.
- ***Scheme-related***: mathematics is a group of terms, rules and formulae. Procedures and rules work as a 'toolbox' central for solving tasks.
- ***Process-related***: mathematics is a problem-solving science where structure and regularities are discovered. Discovering new connections, rules and terms are central for problem-solving.
- ***Application-related***: mathematics is a science relevant to life. Solving daily tasks and problems are central (Felbrich et al., 2008).

The two first orientations can be seen as static and the other two dynamic (Tossavainen et al., 2021ab). In this study, obstacles in the category *advanced mathematics* can be attributed to these beliefs about mathematics. This could mean that different belief orientations may prompt different difficulties, and also, seen from the opposite direction, that different difficulties reveal different belief orientations. For example, students with a static view (formalism- or scheme-related) might experience obstacles when there is much *new content*, because they have to learn a greater number of concepts and procedures in order to think and solve tasks. Thus, the students in my study that claimed *new content* to be an obstacle, may hold a static view on mathematics. In the same way, students with a dynamic view (process- or application-related) may experience obstacles with *more difficult* content or a *faster pace*, because they have to discover more difficult connections and rules, faster than before, for problem-solving. Therefore, the students in this study who saw obstacles with a *more difficult* content or a *faster pace*, could have a dynamic view on mathematics.

Advanced mathematics and epistemological obstacles

Brousseau (1997) makes a distinction between didactical obstacles, resulting from flaws in instruction, and epistemological obstacles, which are impossible to avoid because of the nature of how human knowledge develops (see also Harel & Sowder, 2005). Brousseau (1997) describes such obstacles as "[o]bstacles of really epistemological origin are those from which one neither can nor should escape, because of their formative rôle in the knowledge being sought" (p. 9). The theory of epistemological obstacles is in line with the characteristics of the obstacles in the category *advanced mathematics*. When mathematics becomes more advanced in the course Ma2b, the demand for more advanced thinking increases as well. Harel and Sowder (2005) define advanced mathematical thinking by contrasting it to what must be seen as elementary thinking and find that "[i]t is extremely difficult to characterize these properties, even if we share an intuitive understanding of their meaning, and it is even more difficult to build a taxonomy that differentiates among properties of mathematical thinking" (Harel & Sowder, 2005, p. 33). The term *advanced*, they say, implies a process of development and therefore the term is relative instead of absolute. Moreover, advanced thinking develops gradually and can also be local, so that a high level of mastery within a certain way of thinking can be accompanied by a lower level in another (Harel & Sowder, 2005). Considering this, together with the progression in the curricula from Ma1b to Ma2b, and through the eyes of the students experiencing the obstacles in the category *advanced mathematics*, it is reasonable to identify how demands for more advanced thinking and advanced understanding (Harel & Sowder, 2005) can be seen as epistemological obstacles (Schneider, 2020). Hence, epistemological obstacles should be of importance to these findings.

Advanced mathematics and threshold concepts

This group of obstacles seem to be related to problems concerning specific concepts in mathematics, often referred to as *threshold concepts*, which might occur more frequently in Ma2b than in Ma1b. Threshold concepts are defined by Meyer and Land (2005) as 'conceptual gateways' which lead to thinking that earlier was inaccessible. For various reasons, the change in understanding that is necessary for a student to grasp the concepts can be troublesome. Almost half of the students in the study mentioned the obstacles *new content* and *more difficult*. According to my experience, students often have problems understanding some of the most important concepts in the course, such as functions and logarithms. Therefore, the findings point to the existence of threshold concepts, or at least troublesome concepts, in Ma2b. It takes a lot of examination to elude whether a concept is a threshold concept or not, but it is possible to argue that some concepts in the course can be seen as troublesome (Loch and McLoughlin, 2012; Scheja & Pettersson, 2010). Both Pettersson (2012) and Breen and O'Shea (2016) identify *functions* as being a threshold concept, and functions are of great importance in the course Ma2b. Long (2009) also includes fractions, ratios, proportions and percentages, concepts that the participants in this study already met in compulsory school. Still, there are quite a few students who struggle with understanding these concepts all through the gymnasium. Thus, it is reasonable to be aware of threshold concepts when discussing obstacles.

Advanced mathematics and new content

The course Ma2b contained plenty of new content, meaning topics that were, to a great extent, unfamiliar to the students. Table 9 shows an excerpt of a comparison of the core content in Ma1b and Ma2b (Skolverket, 2012), see the Appendix, where content that can be seen as unfamiliar to the students when starting the course is highlighted. The comparison was also discussed with other mathematics teachers at my school and another school, to verify that the comparison was largely agreed on.

Table 9. *An excerpt of core content in courses Ma1b and Ma2b. Highlighted content are unfamiliar to students when the course starts (Skolverket, 2012).*

Ma1b	Ma2b
Understanding of numbers, arithmetic and algebra • Properties of a range of whole numbers, different number bases, and the concepts of prime numbers and divisibility. • Methods of calculating in everyday life and for subjects typical of programmes, real numbers written in different forms, including powers with integer exponents, and strategies for using digital tools. • Processing of algebraic expressions and formulae relevant to subjects typical of programmes. • The concept of linear inequality. • Algebraic and graphical methods for solving linear equations and inequalities and exponential equations.	**Understanding of numbers, arithmetic and algebra** • Methods of calculating with powers with rational exponents. • The concept of logarithms in solving exponential functions. • Methods for calculating budgets. • Linear equations and how analytical geometry links together geometric and algebraic expressions. • The concept of linear equations. • Handling the rules for squaring and factorising when solving equations. • Extension of the number area through the introduction of the concept of complex numbers in connection with solving second-degree equations. • Algebraic and graphical methods for solving exponential and second-degree equations, and also linear equation systems.

Note that Table 9 shows core content prior to August 2021. A revised curriculum was implemented in August 2021, where some changes were made in order to reduce the overlap between the compulsory school's content and Mab (Skolverket, 2021c), and as a result, some of the content listed under Ma1b above has been deleted and replaced by some of the content listed under Ma2b above (Skolverket, 2021abc). However, the changes (Carlbaum, 2020; Skolverket, 2021ac) in the core contents of Ma1b and Ma2b are not extensive. Thus, it is reasonable to believe that the content in the course Ma2b will be seen as new by the students henceforth as well.

Emotion ≈ students' affect

The six obstacles in the category *emotion* are easily compared to the presumed area called *students' affect*, which has to do with students' beliefs, feelings, values and attitudes, based on research about self-efficacy (see for example Bandura, 1977, 1994, 2005; Bandura & Locke, 2003; DiNapoli, 2018: Grootenboer-Marshman, 2016), perseverance (see for example DiNapoli, 2018; Duckworth et al., 2007; Dweck, 2015) and anxiety (see for example Ashcraft, 2002; Ashcraft & Krause, 2007; Cribbs et al., 2021; Grootenboer-Marshman, 2016; Huang et al., 2019; Wang et al., 2018).

There is a lot to discuss, such as self-efficacy being a predictor of academic achievement (see for example Bandura & Locke, 2003; DeMoulin, 1993). However, I will focus on a few prompts that concern the three obstacles that have the highest frequencies in the category *emotion*. These are: *motivation*, *difficult to get help* and *stressful*. Motivation and stress are both addressed by DeMoulin (1993) who describes a model for self-efficacy that is powered by the three components motivation, confidence and stress, as shown in a reproduction of his 'Efficacy Model' in Figure 1.

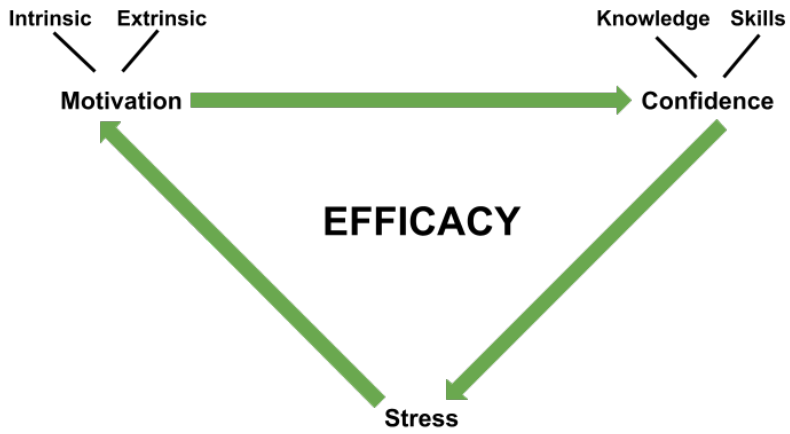

Figure 1. *DeMoulin's Efficacy Model (1993)*

Motivation is, according to DeMoulin (1993) and Hickman and Sherman (2019), generated by

- intrinsic factors, meaning motivators that occur within a person, such as a feeling of pride and satisfaction when trying hard and achieving a goal;
- extrinsic factors, meaning motivators external to the person, such as pay, respect and making career; or
- a mix of both.

Students who possess high motivation have positive feelings and are willing to work hard to complete a task successfully. Students with low motivation express displeasure toward the task and seem uninterested or unwilling to complete it (DeMoulin, 1993; Hickman & Sherman, 2019).

Confidence is the second part in DeMoulin's model, and "is generated by the amount of **knowledge** possessed concerning a specified task and by the level of **skill** needed to successfully fulfill the desired outcome" (DeMoulin, 1993, p. 175). Also, confidence concerns individual beliefs about capabilities, based on earlier experience (DeMoulin, 1993; Grootenboer-Marshman, 2016). Earlier, I wrote about my experience with students who show different levels of self-confidence in mathematics. This resembles well DeMoulin's ideas of how confidence is affected by motivation. It could be suggested that the implication may also be reversed, so that the level of confidence affects the motivation, which is illustrated by David's comment:

> *Sometimes it was hard to get help, when you got stuck on a problem and there were like five others before you, so you completely lost your motivation and then you kind of watched YouTube or did something else and then… the lesson is over.*

When pointing out that he got stuck, this may have revealed low confidence since the knowledge or skill needed was insufficient. Therefore, he needed help. When he did not get help quickly enough, David lost his motivation. The obstacle *difficult to get help* is an example of how confidence influences motivation, the reversed direction of DeMoulin's model.

The third part in DeMoulin's model is stress, which refers to a "physiological and/or psychological response to some outside stimuli which is perceived as a threat" (DeMoulin, 1993, p. 177). Stress can encourage or discourage a certain response, and works differently in different persons, where day-to-day stressors seem to hinder performance for some (DeMoulin, 1993). This is what some of the students reported, when mentioning the obstacle *stressful*. It could be important to acknowledge that some of these students talked about the obstacle *faster pace* in conjunction with stress as Elizabeth, who commented, "We would have needed a week to learn […] it feels like you rush through everything". It is also interesting to notice that stress could contribute to motivation, as shown in William's and Christopher's comments:

William: But when I do it by myself… I need someone to push me a bit, then it works, or have something that stresses, like at the end of the year, otherwise I am bad at self-discipline.
Christopher: *I am best at studying before a test, sort of, when there is a bit of stress, I find it difficult planning…*

Finally, it should be noted that, as stated by Hickman and Sherman (2019), a person's placement on the scales for motivation, confidence and stress varies over time and therefore affects the level of the self-efficacy (Hickman & Sherman, 2019). As a teacher, one notices that students' motivation and confidence change over time and due to the topics. However, in a study where a student who initially said that she experienced mathematics anxiety, Andersson et al. (2015) found that "her past experiences affected her ability to change her affective responses to mathematics on a long-term basis, even if she was able to do so in this particular case" (p. 155). Thus, changing one's perceptions of motivation and confidence seem to demand a lot of work for such changes to become permanent. Obstacles concerning emotion are therefore worth discussing.

Novel teaching + assessment ≈ students' views on mathematics teaching

The obstacles in the two categories *novel teaching* and *assessment* all have to do with problems that arise when there is something about the teaching that does not work out well from the students' perspective. Unfamiliarity or changes in teaching environment (such as *online school*), methods (such as *flipped classroom*) or tools (such as *digital books* or *new tests*), all seem to interfere with how students expect things to be done. Violating norms and breaking didactical contracts (see for example Bennet & Löwing, 2015; Blomhøj, 1994; Brousseau et al., 2020; Fuadiah et al., 2017; Yackel & Cobb, 1996) are seen as obstacles. Also, assessment practices belong to teaching, since evaluating students' knowledge is a part of the teaching (see for example Black & Wiliam, 1998, 2009; Hodgen & Wiliam, 2006; Pettersson, 2010; Sutherland, 2007). Even though *novel teaching* and *assessment* were categorised as two different groups of obstacles, I recognise that the overall problem in both categories have to do with the students' views on how teaching should be practised. As discussed earlier, changes can lead to problems and in this category the three most frequent obstacles, *online school*, *flipped classroom* and *new tests*, will be discussed.

Novel teaching and online school

When the pandemic (covid-19) struck Europe in spring 2020, the gymnasium and higher education switched to online school from March to June, when the students in this study were at the end of their second year, and thus, studying the course Ma2b. In Sweden, most students have access to wi-fi and all students at our school have a school computer. The educational equity considering digital availability (Ezra et al., 2021) was therefore at top level.

Overnight, we were forced to teach online. The term *emergency remote teaching* implies that this is different from what is otherwise typically called online education, that has been studied for decades (Hodges et al., 2020).

> *In contrast to experiences that are planned from the beginning and designed to be online, emergency remote teaching (ERT) is a temporary shift of instructional delivery to an alternate delivery mode due to crisis circumstances. […] The primary objective in these circumstances is not to re-create a robust educational ecosystem but rather to provide temporary access to instruction and instructional supports in a manner that is quick to set up and is reliably available during an emergency or crisis.* (Hodges et al., 2020, retrieved 2022-04-16 at 10.35 AM).

At our school, we did not change the schedule. Instead, we continued the 'ordinary' teaching online, facilitated through video meetings, where we demanded that the students had their cameras on to get attendance. Of course, changes were done in how the lessons were organised in an online environment (see for example Ezra et al., 2021; Martin et al., 2022; Means et al., 2014), but this was up to each teacher to plan.

No matter how well planned and apprehensive the teaching was, the students had all their lessons, in all of their courses, completely online for months. Young people were staying at home all day, which meant that they had their school time and their free time in the same place (Büchele et al., 2021) either alone or together with other family members, both of which had its disadvantages. The result from this study shows that 27% of the students believed the online school to be an obstacle for their learning.

Novel teaching and flipped classroom

The findings show that some students thought that flipped classroom was an obstacle to their learning. Important to highlight here is that a flipped classroom model (Weinberg & Thomas, 2018) was not properly, or successfully, implemented since I rather quickly recognised that only a few students in each class watched the videos accessible to them before class, as planned. As soon as this was revealed, I went back to providing instructions, explanations and worked examples in class. But, since the students still had access to video lectures, I tried to keep the teacher-led parts quite short where possible, reminding and encouraging the students to watch videos with basic instruction if needed. Also, if a student had missed a previous lesson, they were required to watch the video before asking for help. Thus, the flipped classroom model did not work out as intended. Instead, the videos were used as extra resources that were available for the students to use as they preferred. It is interesting that 16% of the students still believed the flipped classroom model to be an obstacle.

Novel teaching, assessment and new tests

The year when these students were studying the course Ma2b, the mathematics teacher team at my school decided to start using cumulative tests, as mentioned earlier. During the year, four tests were undertaken, each test adding previous content to the new. This way of testing knowledge cumulative was a new experience to these students, since they were used to the common way of being assessed through unit tests, where separate areas of content were tested at each test, which often corresponded to one or two chapters in the textbook (Alfredsson et al., 2017). This novel way of testing makes the findings concerning the obstacle *new tests* somewhat difficult for others to use as hypotheses for obstacles in general, which is important to notice. Nevertheless, the findings in this study can still provide knowledge about how changes in assessment may be seen as obstacles to some students.

Earlier research concerning cumulative tests show, among other things, that students who expect a final exam perform better than those who do not (Lawrence, 2013, 2014; Szpunar et al., 2007). Beagley and Capaldi (2016) studied, in addition to Lawrence's research, the benefits of cumulative semester tests compared to unit semester tests on the final exam in an introductory mathematics course, with resembling positive findings for low scoring students' results. Another study on undergraduate medical students (Kerdijk et al., 2015) concludes that a cumulative test "encourages students to distribute their learning activities over a course, which leaves them more opportunity to study the content of the last part of the course prior to the final examination" (Kerdijk et al., 2015, p. 709). These researchers also found that students in the cumulative assessment group spent more time on self-study than students in the final exam group during almost the entire time period of the study (Kerdijk et al., 2015).

Considering these remarks, changing the way the testing was done was seen as an obstacle to 29% of the students, for at least two reasons. Firstly, changes may be perceived as violating classroom norms or breaking didactical contracts (see for example Blomhøj, 1994; Brousseau et al., 2020; Yackel & Cobb, 1996) and second, cumulative tests may be perceived as more demanding than unit tests. Either way, *new tests* can be troublesome to some students.

Managing workload ≈ unexpected area

What was not expected when planning the project, was to find obstacles in the category *managing workload*. Thus, the title *unexpected area* is used in the tables in this section. In this study, the exploratory approach truly proved to be a great asset for the output. The research design, which was not bound by predetermined theories and frameworks, allowed a previously unconsidered category to emerge. Almost a quarter of the utterances in the study, belonging to the category *managing workload*, would have been undiscovered with a different design, for example a quantitative survey study, using questionnaires with multiple choice questions, where all options already were decided.

Defining workload

Since the category *managing workload* was unexpected, the search for previous studies began after analysing the data. This was quite troublesome, partly because there is not one unambiguous definition of the term workload and partly because there is no objective way of measuring workload. Some of the studies about workload focus on how workload influences students' success (Anthony, 2000; Harris et al., 2004) or quality of learning (Chambers, 1992), while others focus on how workload influences students' evaluations of higher educational courses (Dee 2004, 2007; Greenwald & Gillmore, 1997). There are also studies that focus on factors that influence students' views, or perceptions, of their workload (Kember, 2004; Kyndt et al., 2014). The difficulties with defining and measuring workload are noticeable in all of these studies, but such findings are still important to acknowledge in relation to my study.

Workload in an educational setting is often defined as the amount of work required for a course, sometimes referred to as the total amount of work, both in school and outside school, and sometimes workload only refers to the work done outside school. Either way, such work can be individual practice, homework and other kinds of tasks, and it is measured through self-reports of how much time students spend on the course work (see for example Dee, 2004, 2007; Greenwald & Gillmore, 1997). The definition, 'amount of work', combined with the measure, 'time spent', goes well with the students' answers in this study where the obstacles *more work needed* and *problems prioritising* have the highest relative frequencies, 35% and 27% respectively, in the category *managing workload*. The first obstacle, *more work needed*, shows that students had problems with the amount of work that they would need to do, and the second obstacle, *problems prioritising,* shows that students found it difficult to prioritise this work.

Factors affecting the workload

Although time seems to be a crucial factor, Kember (2004) argues that it is not the only factor that influences how students perceive the pressure that comes with a heavy workload. There are other variables that have to do with curriculum and the teaching and learning environment that are important. For example, the course design, the content and its difficulty can affect the perception of workload (Chambers, 1992), and the teaching and learning environment can influence the level of morale (Kember, 2004). An example of such an environment already mentioned is *online school*, which could risk increasing the workload (Büchele et al., 2021). On the other hand, *flipped classroom* is a model for teaching and learning where one of its intentions is to reduce homework. Ölmefors and Scheffel (2021) studied what perspectives on *flipped classroom* students in the Swedish gymnasium have and found that most of the students believed that this model made their workload more consistent and manageable (Ölmefors & Scheffel, 2021). Although influences by curriculum and the teaching and learning environment are done on whole classes or groups, there are also individual differences as to how workload is perceived, which means that a student who spends less time on course work compared to another student may experience a higher workload, and vice versa (Kember, 2004).

This shows that factors that cause workload are not that easy to identify and isolate and that there is a wide range of aspects that may influence workload. Chambers (1992) also points out that workload seems to accommodate "a number of stresses students feel" (p. 146) which does not make the term workload easier to define. Altogether, this highlights difficulties in grasping the unexpected category *managing workload*, which makes further examinations even more important when 60% of the students believe this to be troublesome.

Reflection on methods

When planning the study, I reflected on some risks due to the design and methods. Revisiting some of the concerns about the study will help interpreting the findings.

Generalisability and small sample

The generalisability of the findings is important to discern when making hypotheses about obstacles that students on the EP typically believe that they encounter in Ma2b. The participants in this study form a small sample of the entire population of students on the EP. Therefore, the obstacles found in this study constitute a subset of all possible obstacles that may occur within the entire population. The diagram to the left in Figure 2 shows the risk that the obstacles only form a small subgroup of all obstacles, while the diagram to the right suggests that they might cover most of all obstacles that appear in the population.

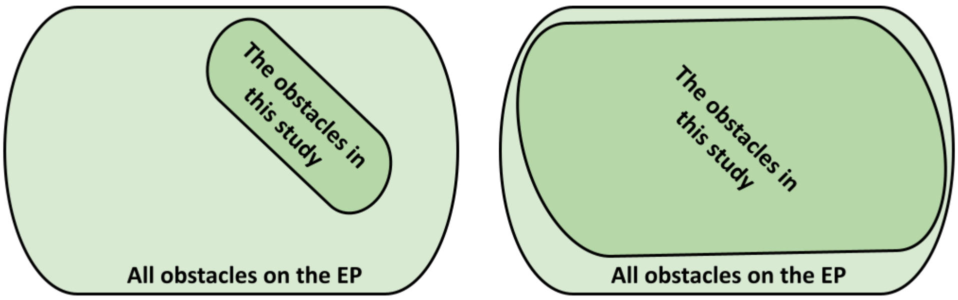

Figure 2. *The subgroup of the obstacles in this study as a subgroup of all the possible obstacles, two examples.*

One may argue that the obstacles found in this study in vital parts can be different to the obstacles appearing in the entire population. However, there are two important aspects of the findings that will add to the certainty about the results. Firstly, the fact that no new codes were found after nine of the sixteen interviews means that data saturation was reached (see for example Cope, 2020; Glaser & Strauss, 1973; Guest et al., 2006; Kenealy, 2012; Martínez-Sierra & García-González, 2017; Prigol & Behrens, 2019; Timonen et al., 2018; Vollstedt-Rezat, 2019). If new obstacles were found in each new interview, the possibility of even more obstacles to occur within the population would be greater. Instead, the opposite can be argued. Because of data saturation after as few as nine interviews, the possibility for new obstacles to occur should be lower. Secondly, it is important to recognise that almost all five synthesised categories were covered in all group conversations. Altogether, this indicates that the results of this study can form a base for building hypotheses about what obstacles students on the EP will experience in Ma2b to a reasonable level of certainty.

Generalisability and biases

If another researcher should conduct the interviews, instead of the students' own teacher, the result may include obstacles concerning the teacher or the teaching, as mentioned earlier. Due to biases, the students in this study might have avoided such obstacles. The result also points in this direction, since none of the students uttered obstacles that had to do with bad teaching. This fact adds to the fragility of representativeness, as a result of the method.

Thick descriptions or not?

The students had as much time as they wanted when we conducted the interviews. The interviews lasted between 8 and 18 minutes, with a mean duration of 13 minutes. There was no stress, and the group atmosphere was friendly and warm. Therefore, the students had the opportunity to carefully elaborate on each of the obstacles that were uttered. Some groups also did. These were the groups that tended to focus on a few obstacles. Other groups rushed through the obstacles without giving many explanations, or they returned to the same obstacle over and over, repeating what they recently said. I was worried that this would not result in thick descriptions (Mills et al., 2010; Stake, 2010) as planned. One obvious cause for not collecting as thick descriptions as desired, was the novice interviewer. However, through the process of coding, by constant comparison, coherent pictures with descriptions about each of the obstacles took shape, almost by itself, in front of my eyes. They may or may not be thick. But at a personal level, I have gained in-depth understanding, *verstehen* (Stake, 2010), for what obstacles my students experienced.

Two levels of analysis

The conversations showed that the students did not separate different obstacles from each other as clearly as I had hoped, which at first seemed like a big problem. It was indeed difficult to perform the first level of the coding, and I sometimes struggled to decide how to separate obstacles emerging in the same statement from a student.

However, when digging deeper into the data derived from the interviews, it became clear that several obstacles truly belonged to the same categories, which was exactly what the students' sometimes seemingly unclear answers revealed. Therefore, the second level of analysis, the categorisation, became a necessity to be able to better frame the nature of the obstacles, since several of them tended to be naturally interleaved. One may argue that the second level of coding is problematic, since it by nature is not as objective as the first level. Grouping the nineteen codes into five categories also helped recognising an unexpected finding, when comparing the categories to the presumed areas.

Implications for practice

Knowledge about what obstacles students experience will hopefully be of help to every person who is interested in understanding students' everyday life in a mathematics classroom and in school in general. People who may share this interest would be students, teachers, school leaders and decision makers at different levels within the system of education and in politics. What decisions can be made from an individual level to a collective level, in order to reduce negative impact of such obstacles? To answer this question properly, further research will be needed to unpick the causes of the experienced obstacles and the connections they have to the learning outcome. Nevertheless, by focusing on the question 'How can obstacles be reduced?' in the light of the results of this study, I would like to offer some implications for practice, accompanied by a few comments from students, in Table 10. It is important to remember that there are intersections between the categories of obstacles as a result of the interleaved nature of the obstacles that build the categories.

Table 10. *Categories of obstacles and some implications for students, teachers, school leaders and decision makers illustrated by students' voices.*

Category *(% of students)*	**Implications for students (S), teachers (T), school leaders (L) and decision makers (D)**	**Students' voice**
Advanced mathematics *(84%)*	S: Be sure to have rich knowledge from the previous course and be prepared to work harder than before. T: Teach at the best of your ability. L: Offer enough time, which can be more than what is demanded as a minimum. D: Evaluate the syllabus with regards to the content and/or the time frames.	Jeffrey: "The difference between year one and two was that year one had a lot of repetition while a lot in year two was new, and you were not prepared for that step."
Managing workload *(60%)*	S: Plan your homework to make sure you do more mathematics. T: Help students plan their homework and urge your school leaders to offer enough time.	Linda: "It is difficult with several things in the same week, it is difficult to prioritise."

	L: Offer enough time and develop a school culture that appreciates studying. D: Evaluate all syllabi due to the core content and/or the number of courses in the programme and/or the time frames.	
Novel teaching ***(45%)***	S: Follow your teacher's instructions about models and tools and learn how to use them well. T: Try out new models and tools carefully, teach students to use them and explain why changes are done. Evaluate properly and abandon things that do not work. L: Promote evaluations of teaching models and tools and leave as many decisions as possible to the professionals. P: Promote research and leave as many decisions as possible to the professionals.	Paul: “Online school was harder, for example to get help during lessons.”
Emotion ***(34%)***	S: Plan your homework to make sure you do more mathematics. T: Help students plan their homework, teach at the best of your ability and make sure the classroom management works. L: Offer enough time and develop a school culture that appreciates studying. D: Evaluate all syllabi with regards to the core content and/or the number of courses in the programme and/or the time frames.	Kevin: “I had a hard time finding motivation, I am not a maths person, you know, I did not find it enjoyable.”
Assessment ***(19%)***	The same as for *novel teaching*	Daniel: “Yes, for each test it became more difficult.”

Further research

As a mathematics teacher I often wonder why students do not study harder as soon as they experience a more difficult content. Why do they not adapt their study habits to the demands of the course at hand? As pointed out before, this study does not answer the initial question of interest that inspired me. Why are students on the EP low achieving in mathematics? Finding causal relationships, if any such exist, between obstacles that students’ experience and their results in the mathematics courses would be interesting for all who care about the students.

Before proceeding to the bigger questions of causalities, it would also be helpful if similar studies were conducted in other schools, geographical or socio-economic areas due to the concerns about generalisability. Furthermore, if others were to conduct similar studies, it would be interesting to know if the findings will depend on whether the interviewer is the teacher or not. The delimitation to focus entirely on the course Ma2b was necessary for this study to be carried out due to the organisational constraints. It would therefore be interesting to consider further research about what is hindering students in course Ma3b as well.

References

Alfredsson, L., Bråting, K., Erixon, P. & Heikne, H. (2017). *NOKflex Matematik 2b*. Natur & Kultur Digital. Retrieved from https://www.nok.se/titlar/laromedel-b3/nokflex-matematik-sa-ek-es-hu/

Anastas, J. W. (1999). *Research Design for Social Work and the Human Services* (2nd ed.). Columbia University Press. https://doi.org/10.7312/anas11890

Andersson, A., Valero, P., & Meaney, T. (2015). "I am [not always] a maths hater": Shifting students' identity narratives in context. *Educational Studies in Mathematics, 90*(2), 143–161.

Andrews, P. & Larson, N. (2017). Analysing genomgång: a Swedish mathematics teaching lesson event. *Nordic Studies in Mathematics Education, 22*(3), 85–105.

Anthony, G. (2020). Factors influencing first-year students' success in mathematics. *International Journal of Mathematical Education in Science and Technology, 31*(1), 3-14.

Antonijevic, R. (2016). Cognitive Activities in Solving Mathematical Tasks: The Role of a Cognitive Obstacle. *EURASIA Journal of Mathematics, Science & Technology Education, 12*(9), 2503–2515.

Ashcraft, M. H. (2002). Math Anxiety: Personal, Educational, and Cognitive Consequences. *Current Directions in Psychological Science*, *11*(5), 181–185.

Ashcraft, M. H., & Krause, J. A. (2007). Working memory, math per- formance, and math anxiety. *Psychonomic Bulletin & Review, 14*(2), 243–248. https://doi.org/10.3758/BF03194059

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191–215. https://doi-org.ezp.sub.su.se/10.1037/0033-295X.84.2.191

Bandura, A. (1994). Self-efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of human behavior* (Vol. 4, pp. 71-81). New York: Academic Press. (Reprinted in H. Friedman [Ed.], *Encyclopedia of mental health*. San Diego: Academic Press, 1998).

Bandura, A. (2005). *Adolescent Development From an Agentic Perspective.* In Pajares, F. & Urdan, T.C. (2006). *Self-efficacy Beliefs of Adolescents (Adolescence and Education) [Elektronisk resurs].* Information Age Publishing, Inc.

Bandura, A., & Locke, E. A. (2003). Negative Self-Efficacy and Goal Effects Revisited. *Journal of Applied Psychology, 88*(1), 87–99.

Beagley, J. E., & Capaldi, M. (2016). The Effect of Cumulative Tests on the Final Exam. Primus: *Problems, Resources & Issues in Mathematics Undergraduate Studies, 26*(9), 878–888. https://doi-org.ezp.sub.su.se/10.1080/10511970.2016.1194343

Bennet, C., & Löwing, M. (2015, november). *Normer under matematiklektioner*. Skolverket. http://matematiklyftet.skolverket.se

Bierema, A., Hoskinson, A.-M., Moscarella, R., Lyford, A., Haudek, K., Merrill, J., & Urban-Lurain, M. (2021). Quantifying Cognitive Bias in Educational Researchers. *International Journal of Research & Method in Education, 44*(4), 395–413.

Bishop, A. What are some obstacles to learning geometry? In: Unesco (1986). *Studies in mathematics education. Vol. 5, Geometry in schools*. Paris: Unesco.

Black, P. J., & Wiliam, D. (1998) Assessment and Classroom Learning, *Assessment in Education: Principles, Policy & Practice, 5*:1, 7-74.

Black, P. J., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability, 21*(1), 5–31.

Blomhøj, M. (1994). *Ett osynligt kontrakt mellan elever och lärare*. Nämnaren, (4), 36-45.

Bonner, E. P., & Adams, T. L. (2012). Culturally responsive teaching in the context of mathematics: A grounded theory case study. *Journal of Mathematics Teacher Education, 15*(1), 25-38.

Breen, S., & O'Shea, A. (2016). Threshold Concepts and Undergraduate Mathematics Teaching. *PRIMUS, 26*(9), 837–847.

Brinkmann, S., & Kvale, S. (2005). Confronting the Ethics of Qualitative Research. *Journal of Constructivist Psychology, 18*(2), 157–181. https://doiorg.ezp.sub.su.se/10.1080/10720530590914789

Brousseau, G. (1997). *Theory of didactical situations in mathematics* (N. Balacheff, M. Cooper, R. Sutherland, & V. Warfield, Eds. & Trans.). Dordrecht, The Netherlands: Kluwer Academic.

Brousseau G., Sarrazy B., & Novotná J. (2020) Didactic Contract in Mathematics Education. In: Lerman S. (eds) *Encyclopedia of Mathematics Education*. Springer, Cham. https://doi-org.ezp.sub.su.se/10.1007/978-3-030-15789-0_46

Büchele, S., Liebendörfer, M., & Lankeit, E. (2021). Increasing the effect of a remedial mathematics course by switching to an online format during the COVID-19 crisis: evidence from a German university. *Teaching Mathematics and Its Applications, 40*(4), 478–496.

Bryman, A. (2012). *Social research methods.* (Fourth edition). Oxford: Oxford University Press.

Carlbaum, B. (2020). *Jämförelse mellan nuvarande version av Gy11 och Skolverkets förslag till revidering* (Examensarbete, Uppsala universitet, Matematiska institutionen). Retrieved from http://uu.diva-portal.org/smash/get/diva2:1394330/FULLTEXT01.pdf

Chambers, E. (1992). Workload and the Quality of Student Learning. *Studies in Higher Education, 17*(2), 141–153.

Cobb, P., & Jackson, K. (2011). Towards an empirically grounded theory of action for improving the quality of mathematics teaching at scale. *Mathematics Teacher Education and Development, 13*(1), 6-33.

Cockcroft, W. H. (1982). Great Britain. Committee of inquiry into the teaching of mathematics in schools (1982). *Mathematics counts: report of the Committee of inquiry into the teaching of mathematics in schools under the chairmanship of W.H. Cockcroft.* London: HMSO.

Cohen, L., Manion, L. & Morrison, K. (2018). *Research Methods in Education*. (8. ed.) Milton Park, Abingdon, Oxon, [England]: Routledge.

Creswell, J.W. (2009). *Research design: qualitative, quantitative, and mixed methods approaches*. (3. ed.) Thousand Oaks, Calif.: Sage.

Cribbs, J., Huang, X., & Piatek-Jimenez, K. (2021). Relations of Mathematics Mindset, Mathematics Anxiety, Mathematics Identity, and Mathematics Self-Efficacy to STEM Career Choice: A Structural Equation Modeling Approach. *School Science and Mathematics, 121*(5), 275–287.

Cope, M. (2020). Transcribing, Coding, and Analyzing Qualitative Data. *Encyclopedia of Human Geography*, 357–362. https://doi-org.ezp.sub.su.se/10.1016/B978-0-08-102295-5.10875-3

Dalen, M. (2015). *Intervju som metod*. (2., utök. uppl.) Malmö: Gleerups utbildning.

Dee, K. C. (2004). Reducing the workload in your class won't "buy" you better teaching evaluation scores: Re-refutation of a persistent myth. *ASEE Annual Conference Proceedings*, 11853–11874.

Dee, K. C. (2007, January 1). Student Perceptions of High Course Workloads are Not Associated with Poor Student Evaluations of Instructor Performance. *Journal of Engineering Education -Washington-, 96*(1), 69–78.

DeMoulin, D. F. (1993). Re-conceptualizing the self-efficacy paradigm: analysis of an eight-year study. *Education, 114*(2), 167+. https://link.gale.com/apps/doc/A15324589/AONE?u=anon~563faed0&sid=googleScholar&xid=4da7de92

DiNapoli, J. (2018). Supporting Secondary Students' Perseverance for Solving Challenging Mathematics Tasks. *North American Chapter of the International Group for the Psychology of Mathematics Education.*

DiNapoli, J. (2019). Persevering toward What? Investigating the Relationship between Ninth-grade Students' Achievement Goals and Perseverant Actions on an Algebraic Task. *International Electronic Journal of Mathematics Education, 14*(3), 435-453. https://doi.org/10.29333/iejme/5747

Dossey, John. (1992). *The nature of mathematics: Its role and its influence*. Retrieved from https://www.researchgate.net/publication/243769794_The_nature_of_mathematics_Its_role_and_its_influence

Duckworth, A. L., Peterson, C., Matthews, M. D., & Kelly, D. R. (2007). Grit: Perseverance and Passion for Long-Term Goals. *Journal of Personality & Social Psychology, 92*(6), 1087–1101. https://doi-org.ezp.sub.su.se/10.1037/0022-3514.92.6.1087

Dweck, C.S. (2015). *Mindset: du blir vad du tänker.* (Första utgåvan). Stockholm: Natur & Kultur.

Ezra, O., Cohen, A., Bronshtein, A., Gabbay, H., & Baruth, O. (2021). Equity factors during the COVID-19 pandemic: Difficulties in emergency remote teaching (ert) through online learning. *Education and Information Technologies: The Official Journal of the IFIP Technical Committee on Education, 26*(6), 7657–7681. https://doi-org.ezp.sub.su.se/10.1007/s10639-021-10632-x

Felbrich, A., Müller, C., & Blömeke, S. (2008). Epistemological beliefs concerning the nature of mathematics among teacher educators and teacher education students in mathematics. *ZDM: The International Journal on Mathematics Education, 40*(5), 763–776. https://doi-org.ezp.sub.su.se/10.1007/s11858-008-0153-5

Flyvbjerg, B. (2013). *Five Misunderstandings About Case-Study Research*. https://doi-org.ezp.sub.su.se/10.1177/1077800405284363

Fuadiah, N. F., Suryadi, D., & Turmudi (2017). Analysis of Didactical Contracts on Teaching Mathematics: A Design Experiment on a Lesson of Negative Integers Operations. *Infinity, 6* (2), 157-168. doi:10.22460/infinity.v6i2. p157-168

Glaser, B.G. & Strauss, A.L. (1973). *The discovery of grounded theory [Elektronisk resurs]: strategies for qualitative research.* New Brunswick, N.J.: Aldine Transaction (a division of Transaction Publishers.

Greenwald, A. G., & Gillmore, G. M. (1997, January 1). No Pain, No Gain? The Importance of Measuring Course Workload in Student Ratings of Instruction. *Journal of Educational Psychology, 89*(4), 743–751.

Gray, E., & Tall, D. (2007). Abstraction as a Natural Process of Mental Compression. *Mathematics Education Research Journal, 19*(2), 23–40.

Grootenboer, P. & Marshman, M. (2016). *Mathematics, Affect and Learning Middle School Students' Beliefs and Attitudes About Mathematics Education.* (1st ed. 2016.) Singapore: Springer Singapore.

Guest, G., Bunce, A., & Johnson, L. (2006). *How many interviews are enough? An experiment with data saturation and variability.* Field Methods, 18(1), 59–82.

Harel, G., & Sowder, L. (2005, January 1). Advanced Mathematical-Thinking at Any Age: Its Nature and Its Development. *Mathematical Thinking and Learning, 7*(1), 27–50.

Harris, D. E., Hannum, L., & Gupta, S. (2004). Contributing Factors to Student Success in Anatomy & Physiology: Lower Outside Workload & Better Preparation. *The American Biology Teacher, 66*(3), 168–175. https://doi-org.ezp.sub.su.se/10.2307/4451650

Hatisaru, V. (2019). Lower Secondary Students' Views about Mathematicians Depicted as Mathematics Teachers. *LUMAT: International Journal on Math, Science and Technology Education, 7*(2), 27–49.

Hickman, C. J., & Sherman, H. J. (2019). *Learning mathematics successfully : Raising self-efficacy in students, teachers and parents*. Information Age Publishing, Incorporated.

Hodgen, J. & Wiliam, D. (2006). *Mathematics inside the black box.* Bedömning för lärande i klassrummet. Svensk översättning 2010.

Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020). The difference between emergency remote teaching and online learning. Educause. Retrieved from https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning.

Huang, X., Zhang, J. & Hudson, L. (2019) Impact of math self-efficacy, math anxiety, and growth mindset on math and science career interest for middle school students: the gender moderating effect. *European Journal of Psychology of Education 34*, 621–640. https://doi.org/10.1007/s10212-018-0403-z

Jankvist, U. T. (2015). Changing students' images of "Mathematics as a discipline." *The Journal of Mathematical Behavior, 38*, 41–56. https://doi.org/10.1016/j.jmathb.2015.02.002

Jankvist, U. T., Misfeldt, M., & Marcussen, A. (2016). The Didactical Contract Surrounding CAS When Changing Teachers in the Classroom. *REDIMAT - Journal of Research in Mathematics Education, 5*(3), 263–286.

Kaijser, S. (2002). *Uppfinna eller upptäcka?* Nämnaren, (2), 13-15. Retrieved from http://ncm.gu.se/media/stravorna/7/a/7a_kaijser.pdf

Kaijser, S. (2006, 1 mars). Matematik - uppfunnen eller upptäckt? Forskning & Framsteg, (2). Retreieved from https://fof.se/tidning/2006/2/artikel/matematik-uppfunnen-eller-upptackt

Kandola, B. (2012). Focus groups. In G. Symon, & C. Cassell *Qualitative organizational research* (pp. 258-274). SAGE Publications, Inc., https://dx.doi.org/10.4135/9781526435620.n15

Kember, D. (2004, January 1). Interpreting student workload and the factors which shape students' perceptions of their workload. *S Studies in Higher Education -Oxford-, 29*(2), 165–184.

Kenealy, G. (2012). Grounded theory: a theory building approach. In G. Symon, & C. Cassell *Qualitative organizational research* (pp. 408-425). SAGE Publications, Inc., https://dx.doi.org/10.4135/9781526435620.n23

Kerdijk, W., Cohen, S. J., Mulder, B. F., Muntinghe, F. L. H., & Tio, R. A. (2015). Cumulative versus end-of-course assessment: effects on self-study time and test performance. *Medical Education, 49(*7), 709–716. https://doi-org.ezp.sub.su.se/10.1111/medu.12756

Khiat, H. (2010). A grounded theory approach: Conceptions of understanding in engineering mathematics learning. *Qualitative Report, 15*(6), 1459-1488.

Kunskapsmatrisen. (n.d.) Retrieved from https://www.kunskapsmatrisen.se/

Kvale, S. (2007). *Doing interviews.* SAGE Publications, Ltd https://dx.doi.org/10.4135/9781849208963

Kvale, S., & Brinkmann, S. (2009). *Interviews. Learning the Craft of Qualitative Researcch Interviewing*. (2nd Ed.). Thousand Okas, CA: Sage.

Kyndt, E., Berghmans, I., Dochy, F., & Bulckens, L. (2014). "Time is not enough." Workload in higher education: a student perspective. *Higher Education Research & Development, 33*(4), 684–698.

Larson, N. (2014). *Matematikämnet och stadiebytet mellan grundskolan och gymnasieskolan : En enkät- och klassrumsstudie* [PhD dissertation, Stockholm University]. https://doi.org/10.3384/diss.diva-111872

Lawrence, N. K. (2013). Cumulative Exams in the Introductory Psychology Course. *Teaching of Psychology, 40*(1), 15–19. https://doi-org.ezp.sub.su.se/10.1177/0098628312465858

Lawrence, N. K. (2014). Examining the benefits of cumulative exams. In V. Benassi, C. Overson, and C. Hakala (Eds), *Applying Science of Learning in Education*, pp. 274–278. Washington, DC: American Psychological Association.

Loch, B., & McLoughlin, C. (2012). Teaching threshold concepts in engineering mathematics using MathsCasts. *23rd Annual Conference of the Australasian Association for Engineering Education 2012: Profession of Engineering Education: Advancing Teaching, Research and Careers, The,* 1079–1086. https://doi-org.ezp.sub.su.se/10.3316/informit.9780987177230

Long, C. (2009). From whole number to real number : applying Rasch measurement to investigate threshold concepts. *Pythagoras, 2009*(70), 32–40. https://doi-org.ezp.sub.su.se/10.10520/EJC20918

Lundin, S. (2008). *Skolans matematik: En kritisk analys av den svenska skolmatematikens förhistoria, uppkomst och utveckling.* Doktorsavhandling. Uppsala: Uppsala universitet.

Martin, C. S., Harbour, K., & Polly, D. (2022). Examining How Emergency Remote Teaching Influenced Mathematics Teaching. *TechTrends: Linking Research and Practice to Improve LearningA*

Publication of the Association for Educational Communications & Technology, 1–13. https://doi-org.ezp.sub.su.se/10.1007/s11528-022-00711-2

Martínez-Sierra, G., & García-González, M. del S. (2017). Students' Emotions in the High School Mathematical Class: Appraisals in Terms of a Structure of Goals. *International Journal of Science and Mathematics Education, 15*(2), 349–369. https://doi-org.ezp.sub.su.se/10.1007/s10763-015-9698-2

Means, B., Bakia, M., & Murphy, R. (2014). Learning Online: What Research Tells Us About Whether, When and How (1st ed.). Routledge. https://doi-org.ezp.sub.su.se/10.4324/9780203095959

Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research : A guide to design and implementation*. John Wiley & Sons, Incorporated.

Meyer, J. H. F., & Land, R. (2005). Threshold concepts and troublesome knowledge (2): Epistemological considerations and a conceptual framework for teaching and learning. *Higher Education, 49*, 373–388. doi:10.1007/s10734-004-6779-5.

Mills, A. J., Durepos, G., & Wiebe, E. (2010). *Encyclopedia of case study research* (Vols. 1-0). Thousand Oaks, CA: SAGE Publications, Inc. doi: 10.4135/9781412957397

Mouwitz, L. (2001). *Hur kan lärare lära: Internationella erfarenheter med fokus på matematikutbildning.* Nationellt Centrum för Matematikutbildning. Göteborg: Göteborgs universitet.

Noviani, J. (2021). Perceptions of Mathematics Education Students Toward E-Learning During the Covid-19 Pandemic. *Kalamatika: Jurnal Pendidikan Matematika, 6*(1), 15-30.

Perbowo, K. S., & Anjarwati, R. (2017). Analysis of Students' Learning Obstacles on Learning Invers Function Material. *Infinity, 6* (2), 169-176. https://doi-org.ezp.sub.su.se/10.22460/infinity.v6i2.p169-176

Pettersson, A. (2010). *Bedömning av kunskap: för lärande och undervisning i matematik.* Stockholm: Institutionen för matematikämnets och naturvetenskapsämnenas didaktik, Stockholms universitet.

Pettersson, K. (2012). The Threshold Concept of a Function – A Case Study of a Student's Development of Her Understanding. Retrieved from http://www.math.chalmers.se/Math/Grundutb/GU/L9MA10/V19-1/KerPetFunktion.pdf

Prigol, E. L., & Behrens, M. A. (n.d.). Grounded theory: Methodology applied in education research. *Educacao and Realidade, 44*(3). https://doi-org.ezp.sub.su.se/10.1590/2175-623684611

Schneider, M. (2020) Epistemological Obstacles in Mathematics Education. In: Lerman S. (eds) *Encyclopedia of Mathematics Education*. Springer, Cham. https://doi-org.ezp.sub.su.se/10.1007/978-3-030-15789-0_57

Scheja, M., & Pettersson, K. (2010). Transformation and Contextualisation: Conceptualising Students' Conceptual Understandings of Threshold Concepts in Calculus. *Higher Education, 59*(2), 221–241. https://doi-org.ezp.sub.su.se/10.1007/s10734-009-9244-7

Skolverket. (May 3, 2012). *Ämnesplan på engelska. Matematik*. Retrieved from https://www.skolverket.se/download/18.4fc05a3f164131a74181063/1535372298267/Mathematics-swedish-school.pdf

Skolverket. (2013). *Curriculum for the upper secondary school*. Retrieved from https://www.skolverket.se/publikationer?id=2975

Skolverket. (2017). *Swedish grades*. Retrieved from https://www.skolverket.se/download/18.47fb451e167211613ef398/1542791697007/swedishgrades_bilaga.pdf

Skolverket. (2021a). *Jämför ämnesplanerna. Ämnesplan i matematik på gymnasial nivå*. Retrieved from https://www.skolverket.se/download/18.7f8c152b177d982455e156e/1616170952319/Ja%CC%88mfo%CC%88relsedok_Matematik_gy_Slutversion_tillga%CC%88nglig_NY.pdf

Skolverket. (2021b). *Kommentarmaterial till ämnesplanen i matematik*. Retrieved from https://www.skolverket.se/getFile?file=7841

Skolverket. (September 3, 2021c). *Ändrad ämnesplan i matematik*. Retrieved from https://www.skolverket.se/skolutveckling/inspiration-och-stod-i-arbetet/stod-i-arbetet/andrad-amnesplan-i-matematik#h-Jamforamnesplanerna

Skolverket. (n.d.a). *Läroplan, program och ämnen i gymnasieskolan*. Retrieved from https://www.skolverket.se/undervisning/gymnasieskolan/laroplan-program-och-amnen-i-gymnasieskolan

Skolverket. (n.d.b). *Overview of the Swedish upper secondary school*. Retrieved from https://www.skolverket.se/download/18.6bfaca41169863e6a659a16/1553964183391/pdf2748.pdf

Skolverket. (n.d.c). *Statistik*. Retrieved from https://www.skolverket.se/skolutveckling/statistik

Slavin, R. E. (2015). Cooperative Learning in Elementary Schools. *Education 3-13, 43*(1), 5–14.

Szpunar, K. K., McDermott, K. B., & Roediger, H. L. (2007). Expectation of a final cumulative test enhances long-term retention. *Memory & Cognition, 35*(5), 1007–1013. https://doi-org.ezp.sub.su.se/10.3758/bf03193473

Stake, R.E. (2010). *Qualitative research [Elektronisk resurs] studying how things work.* New York: Guilford Press.

Sutherland, R. (2007). *Teaching for learning mathematics*. Glasgow. Open University Press.
Sverige. Skolverket (2021). *Kommentarmaterial till ämnesplanen i matematik [Elektronisk resurs]*. Stockholm: Skolverket.

Sökande och antagna till gymnasieskolan läsåret 2021/22 [Elektronisk resurs]. (2021). Skolverket.

Timonen, V., Foley, G., & Conlon, C. (2018). Challenges when using grounded theory: A pragmatic introduction to doing GT research. *International Journal of Qualitative Methods, 17*(1), 160940691875808. doi:10.1177/1609406918758086

Tossavainen, T., Rensaa, R. J., Haukkanen, P., Mattila, M., & Johansson, M. (2021a). First-year engineering students' mathematics task performance and its relation to their motivational values and views about mathematics. *European Journal of Engineering Education, 46*(4), 604–617. https://doi-org.ezp.sub.su.se/10.1080/03043797.2020.1849032

Tossavainen, T., Rensaa, R. J., & Johansson, M. (2021b). Swedish first-year engineering students' views of mathematics, self-efficacy and motivation and their effect on task performance. *International Journal of Mathematical Education in Science and Technology, 52*(1), 23–38. https://doi-org.ezp.sub.su.se/10.1080/0020739X.2019.1656827

Vetenskapsrådet (2017). *God forskningssed [Elektronisk resurs]*. (Reviderad utgåva). Stockholm: Vetenskapsrådet. Retrieved from https://www.vr.se/analys/rapporter/vara-rapporter/2017-08-29-god-forskningssed.html

Viholainen, A., Partanen, M., Piiroinen, J., Asikainen, M. & Hirvonen, P. E. (2015). The role of textbooks in Finnish upper secondary school mathematics: theory, examples and exercises. *Nordic Studies in Mathematics Education, 20*(3–4), 157–178.

Vollstedt, M. (2015). *To See the Wood for the Trees: The Development of Theory from Empirical Interview Data Using Grounded Theory*. Springer Netherlands. https://doi-org.ezp.sub.su.se/10.1007/978-94-017-9181-6_2

Vollstedt, M., & Rezat, S. (2019). *An Introduction to Grounded Theory with a Special Focus on Axial Coding and the Coding Paradigm*. Springer International Publishing. https://doi-org.ezp.sub.su.se/10.1007/978-3-030-15636-7_4

Wallin, J., Hafsteinsdottir, E., Samuelsson, J., Bergman, E., Bergman, M., Fundell, S., Gulz, A., Helenius, O. & Jahnke, A. (2017). *Digitala lärresurser i matematikundervisningen, delrapport skola [Elektronisk resurs]* Systematisk översikt 2017:02. Solna: Skolforskningsinstitutet

Wang, Z., Shakeshaft, N., Schofield, K. & Malanchini, M. (2018). *Anxiety is not enough to drive me away: A latent profile analysis on math anxiety and math motivation*. PLoS ONE 13(2): e0192072. https://doi.org/10.1371/journal.pone.0192072

Weinberg, A., & Thomas, M. (2018). Student Learning and Sense-Making from Video Lectures. *International Journal of Mathematical Education in Science and Technology, 49*(6), 922–943.

Xenofontos, C., Andrews, P. The discursive construction of mathematics teacher self-efficacy. *Educational Studies in Mathematics 105*, 261–283 (2020). https://doi.org/10.1007/s10649-020-09990-z

Yackel, E., & Cobb, P. (1996). Sociomathematical Norms, Argumentation, and Autonomy in Mathematics. *Journal for Research in Mathematics Education, 27*(4), 458–477. https://doi.org/10.2307/749877

Ölmefors, O., & Scheffel, J. (2021). High school student perspectives on flipped classroom learning. *Pedagogy, Culture & Society*, 1–18. https://doi.org/10.1080/14681366.2021.1948444

Appendices

Interview guide

When the students come into the room, they are advised to sit at one end of a table, next to each other. The interviewer sits at the opposite side of the table, next to the laptop, and arranges the laptop to make sure that video and sound are working and that all students are visual on the film. This is done as quickly as possible, but it might make the students a bit uncomfortable, so arranging the setup and starting the recording is accompanied by small talk about how they are doing, what lunch they had and so on.

Starting the conversation
The interviewer starts the conversation saying something like: First you studied Ma1b, and last year Ma2b. I would like for you to talk about (or I am interested in knowing or just the question) what obstacles for learning that you experienced during Ma2b and how you acted regarding these obstacles.

If the students seem to have trouble getting started, the interviewer can add something like: Were there any differences between Ma1 and Ma2 that could be seen as obstacles?

If the conversation goes on naturally, the interviewer tries to be passive and just pay attention to what is said.

Helping the conversation
If one student does not seem to engage in the conversation, the interviewer can say something like: What do you say, Evan, were obstacles for you in Ma2b?
If one student takes over the entire conversation, the interviewer can say something like: Okay, Jenny, so that was important for you. What do you say, George, Dinah and Pete, do you have other obstacles to add?

If the students seem to mention the same, few obstacles, or if there is something else that makes the interviewer suspect that there is a risk that someone has another opinion, the interviewer can point out the importance of various views: Remember that you do not have to agree, I am interested in as many different views as possible.

If the students seem to get stuck with one obstacle, or if they seem unengaged in the conversation the interviewer can say something like: You mentioned x as an obstacle, but I wonder if there could have been other obstacles as well if you really look back at the course?

If the students seem to be too polite and avoid obstacles that have to do with the teaching, the interviewer can say something like: Remember that I am really interested in knowing what you really experienced as obstacles. What about teaching?

Ending the conversation
The interviewer has made sure that all students have had the chance to talk during the conversation. When the conversation seems to have come to an end the interviewer checks out that the group has covered both parts of the topic, that is, obstacles as well as actions (solutions). Otherwise, the interviewer has to ask further questions.

The interviewer stops the recording, thanks the students for their participation and reminds them about the voluntariness of their participation.

Consent form

The consent below refers to audio and film recordings during interviews and applies to upper secondary school students' participation in Monica Andersson's research project in the didactics of mathematics, concerning students' learning in Mathematics 2b. All students are at least 16 years old.

I admit that:
• statements approved by me in interviews (anonymised, i.e., without my name)
• film (moving picture where I am visual)
• audio recordings (audio recordings where my voice is heard)

may be used freely by Monica Andersson within the framework of her research project. Monica Andersson is not obliged to inform me when this participation will take place.

I give this consent provided that
• all or parts of my participation will not be used in other contexts than within Monica Andersson's research projects
• I can cancel my participation at any time without having to explain why by notifying Monica Andersson of this orally or in writing

I have read and understood the above conditions and hereby give my consent as above.

Nacka 20__-____-____

Signature:

____

Name clarification:

____

Comparison of core content

Core content in courses Ma1b and Ma2b. Highlighted content are unfamiliar to students when the course starts (Skolverket, 2012).

Ma1b	Ma2b
Understanding of numbers, arithmetic and algebra • Properties of a range of whole numbers, different number bases, and the concepts of prime numbers and divisibility. • Methods of calculating in everyday life and for subjects typical of programmes, real numbers written in different forms, including powers with integer exponents, and strategies for using digital tools.	**Understanding of numbers, arithmetic and algebra** • Methods of calculating with powers with rational exponents. • The concept of logarithms in solving exponential functions. • Methods for calculating budgets. • Linear equations and how analytical geometry links together geometric and algebraic expressions. • The concept of linear equations.

• Processing of algebraic expressions and formulae relevant to subjects typical of programmes.
• The concept of linear inequality.
• Algebraic and graphical methods for solving linear equations and inequalities and exponential equations.

Geometry

• The concept of symmetry and different types of symmetry transformations of figures in a plane, and the occurrence of symmetry in nature and the arts from different cultures.
• Representations of geometric objects and symmetries through words, practical designs and aesthetic expressions.
• Mathematical reasoning using basic logic, including implication and equivalence, and comparisons with how to reason in everyday contexts and in different subject areas.
• Illustration of the concepts of definition, theorem and proof, such as the Pythagorean theorem and the sum of the angles of a triangle.

Relationships and change

• Advanced percentage concepts: per mille, ppm and percentage points.
• The concepts of rate of change and index, as well as methods for calculating interest and amortisation for different types of loans.
• The concept of a function, domain and range of a definition, and also properties of linear functions, and exponential functions.
• Representations of functions, such as in the form of words, shapes, functional expressions, tables and graphs.
• Differences between the concepts of equation, algebraic expressions and functions.

Probability and statistics

• Examination of how statistical methods and results are used in society and in science.
• The concepts of dependent and independent events, as well as methods for calculating probabilities in multi-stage random trials, using examples from games, and risk and safety assessments.

Problem solving

• Strategies for mathematical problem solving including the use of digital media and tools.
• Mathematical problems relevant to personal finances, societal life and applications in other subjects.
• Mathematical problems related to the cultural history of mathematics.

• Handling the rules for squaring and factorising when solving equations.
• Extension of the number area through the introduction of the concept of complex numbers in connection with solving second-degree equations.
• Algebraic and graphical methods for solving exponential and second-degree equations, and also linear equation systems.

Geometry

• Use of fundamental classical theorems in geometry concerning similarity, congruence, and angles.

Relationships and change

• Properties of quadratic functions.
• Construction of graphs for functions and determining a function's value and setting it to zero, with and without digital tools.

Probability and statistics

• Statistical methods for reporting observations and data from surveys, including regression analysis.
• Orientation and discussion of correlation and causality.
• Methods for calculating different measures of central tendency and measures of dispersion including standard deviation.
• Properties of normally distributed material.

Problem solving

• Strategies for mathematical problem solving including the use of digital media and tools.
• Mathematical problems of importance in societal life and applications in other subjects.
• Mathematical problems related to the cultural history of mathematics.

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