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Opportunities and Challenges in Introducing Edtech for Math to Swedish High School Students and Their Teachers

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LINN ENGEN
FILIP JOHANSSON

Department of Technology Management and Economics
Division of Innovation and R&D Management
CHALMERS UNIVERSITY OF TECHNOLOGY
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LINN ENGEN
FILIP JOHANSSON

Supervisor, Chalmers: ANDERS ISAKSSON

Department of Technology Management and Economics
Division of Innovation and R&D Management
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Department of Technology Management and Economics
Division of Innovation and R&D Management
Chalmers University of Technology
SE-412 96 Gothenburg, Sweden
Telephone: + 46 (0)31-772 1000

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Abstract

Problem: Mathematics, or math, is commonly believed to be important both in our everyday and professional lives and as a tool to develop analytical and arithmetic ability from a young age. International comparisons made of mathematical ability among middle- and high school students such as PISA and TIMSS studies indicate declining and/or stagnated results for the Swedish students in international comparison. Math appears to be a highly unfavorable subject for many people. Many papers have studied the presence and effects of psychological factors such as math anxiety and social aspects such as expectations as well as genetic factors on mathematical performance. Since the entrants of the first computers, later internet and various portable computer technology, the use of technology in the classroom has been studied. This type of technology so called Educational Technology is now often referred to as edtech. Even though many studies, Swedish and foreign, show how the use of technology can help students' performance in general and in math in particular, widespread adoption is yet to happen.

Aim: The aim of this study is to explore the opportunities and challenges in introducing edtech for math. Furthermore, the aim is to study how edtech for math is received by high school students and their teachers, mainly from two Swedish high schools. The study is performed with the background of daunting Swedish math results and widespread dislike for math. The aim is therefore also to study students' perception of math as a subject and their study habits.

Literature Review: The literature review starts by reviewing studies of and literature on factors that affect mathematical abilities. Psychological, motivational, social and genetic factors are covered. The second part of the literature review presents previous studies of edtech in and outside of the classroom.

Method: A mixed method was used prior to and after the introduction of an edtech tool for math in two classes. Interviews with teachers, observations of lectures and a survey responded by the students took place before and after the introduction. Group interviews with students were also performed after the students had have access to the tool for approximately one month. The literature review started before the first round of interviews, observations and survey and continued throughout the project period. A pilot study was performed at another high school as to help form the study's content and to test the first survey on students of the right population.

Results: Students that did try the introduced edtech tool felt more confident when getting stuck on an exercise than they did before. However, many students chose to not try the edtech tool introduced. Various reasons for this were identified such as lack of motivation and a large supply of other means of receiving help in math.

Conclusion: There are opportunities in the introduction of edtech for math, especially if the unmotivated students can be motivated with the help of the particular tool. There are also many challenges illustrated by six identified barriers to implementation. These have to do with students' lack of motivation, teachers' negative attitudes towards math, competition from other means of receiving help and so on.

Key Words: Mathematics, education, math anxiety, math confidence, educational technology/edtech, Information and Communication Technology/ICT, CAI/Communication and Information.

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Linn Engen

Filip Johansson

Concepts and Definitions

CBI: Computer Based Instruction (Kulik & Kulik, 1991)

Economics students: Refers to students studying at *Ekonomiprogrammet* at Swedish high schools.

Edtech: or Educational Technology refers to "the use of technology in education, or the design of such technology" (Cambridge Dictionary, 2018) and" software, systems and devices that are used in higher education to support the business of teaching and learning". (King et al., 2015).

Flipped learning: "Flipping the classroom refers to changing the location of the delivery of content, or the direct instruction phase of a teaching and learning cycle" and "flipped learning involves the use of digital technology, such as video, to provide direct instruction on new concepts outside of the classroom". - Straw et al. (2015)

GeoGebra: A software including various functionality such as graph drawing and equation solving. (GeoGebra.org, 2018)

ICT: Information and Communication Technology. (Nationalencyklopedin, 2018)

Math Anxiety: Many people experience unpleasant feeling when it comes to doing math (Dowker, 2004) which is the likely explanation to why it has a name of its own. There are many publications on the subject exploring the reasons behind as well as implications of math anxiety.

mCSCL: Mobile-computer-supported collaborative learning (Sung et al., 2017)

Natural science students: Refers to students studying at *Naturvetenskapsprogrammet* at Swedish high schools.

PISA: The program for International Student Assessment. 72 OECD countries are participating and the test takes place every third year (oecd.org, 2018).

Social science students: Refers to students studying at *Samhällsvetenskapsprogrammet* at Swedish high schools.

TIMSS: International comparison in math performance among fourth and eighth graders in approximately 60 countries. It takes place every fourth year. Stands for "Trends in International Mathematics and Science Study" (Skolverket, 2017).

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1. Introduction

The following chapter will provide a background to the chosen research subject, its context, aim and research questions. The chapter ends with delimitations and disposition.

1.1 Background

Swedish high school students are performing poorly in math, science and reading compared to other OECD countries, especially with historical development considered (Skolverket, 2015). Despite increases in *PISA* scores since 2012, where the performance went from below average to average (Skolverket, 2015), there has been a strong downward trend regarding the Swedish students for more than a decade. Sweden is the country with the largest decline in science and math scores since the PISA tests were first conducted. From performing above average in the year 2000, the Swedish students are now performing at an average level.

Another study typically referred to regarding different countries' performance in math is *TIMSS* (Trends in International Mathematics and Science Study). The study takes place every fourth year (Skolverket, 2015). The most recent test scores were conducted 2015 and reveal that Swedish students, in both grade four and eight, are performing worse than other EU and OECD countries. The scores are eight and eleven points below average in grade four and eight respectively. Furthermore, the Swedish results in math were consistently declining between the years 1995 and 2015. Although there has been a performance increase in recent years the results are still far below those achieved in 1995.

Different reasons for the daunting results have been suggested and discussed by various studies and experts. The Swedish students were among the ones from the participating countries in the 2015 TIMSS study that valued math- and science knowledge the least. The Swedish students' confidence in math knowledge was measured to be declining while still being high in comparison to students from other countries. Swedish teachers that were interviewed in connection to the 2015 study said that their major concern was lack of time to provide individual help. More than 70 percent of the fourth-grade teachers and around 60 percent of the eighth-grade teachers perceived this to be the biggest issue (Skolverket, 2015). Other factors commonly studied alongside performance in math (Sigmundsson et al., 2013) are *math anxiety* (Ashcraft & Krause, 2007; Maloney & Beilock (2012), expectations (You et al., 2015; Eccles & Jacobs, 1986), genetic predisposition (Dowker, 2004) and overall attitudes (Turner et al., 2004; Larkin & Jorgensen 2015). On one hand there is a potential need to improve the way math is taught in Sweden and other countries and on the other hand there is the development of new technology potentially enabling such improvement.

Industry after industry is getting digitalized but education appears to be lagging behind. Roberts (2016) compares education to other fields and concludes that the use as well as the functionality of technology is far from its full potential. He argues that the spread of educational technology, hereinafter *edtech*, has been discouraged by the OECD study from 2015: "Students, Computers and Learning: Making the Connection" that found no positive correlation between the use of computers and performance. According to Roberts (2016) the report only considered the time spent on computers not how they were used.

There are natural explanations for the limited use of new technology in education as schools are funded by tax money and hence free of charge for the Swedish students (Skolverket, 2017). However, there is growing support for edtech both inside and outside the classroom. One approach expressed in a publication made by Skolverket in 2017 is edtech as particularly useful for students with learning difficulties. Digital tools are also believed to facilitate individualized learning for all students (Skolverket, 2017). In addition to this, Roberts (2016) states that edtech while correctly used can be a mean to reduce workload for teachers thus potentially benefiting both students and teachers.

1.2 Research Context

The context of this study is framed by math education and edtech for math, or the gap in between them more correctly. The theoretical background has it that Sweden's overall performance in math is poor; not yet recovered from the decline the last ten years. Simultaneously there have been numerous studies: Skolverket (2017); The Swedish Parliament (Riksdagen, 2016); Straw et al. (2015); Sung et al. (2017); Li and Ma (2005), made in Sweden and elsewhere where the benefits of using technology in learning math appear to greatly outweigh the downsides. There seems to be a delay with which these new technologies are implemented (Pierce and Ball, 2009; Straw et al. 2015; Roberts, 2016).

This study, taking on an exploratory approach, aims to explore abovementioned gap between the reality of math education and the potential use of edtech for math. This is done through a two-sided approach where the current way of learning math in and outside of class is examined to enable a study of how edtech for math is perceived and received by students and teachers. This is enabled through the introduction of an edtech tool. The edtech tool provides the customer/student with videos of solutions for exercises in Swedish high school math books. While using the videos the students do not have to have access to someone to ask for help. The company it is provided by, hereby called MathStudy, is a small enterprise active within the edtech market. It offers its customers monthly subscriptions to its videos. The tool is introduced in two Swedish high school classes, one *economics class* and one *natural science class*. This study is focused on the use of the tool, rather than the technical aspects of it.

1.3 Aim and Research Questions

This study aims to explore various aspects of introducing edtech for math from the perspective of students and teachers. This gives rise to the first and main research question:

Q1. What are the opportunities and challenges in introducing an edtech tool for math to Swedish high school students and their teachers?

In order to answer this question, the perception and reception of edtech for math will be explored, as demonstrated by the second research question:

Q2. How is edtech for math perceived and received by different kinds of Swedish high school students and their teachers?

Given the background of daunting Swedish math results and widespread dislike for math it appears essential to also study the perceptions of math as a subject, since it is believed to

heavily influence the perception and reception of edtech for math. This gives rise to the third research question:

Q3. What are different kinds of students' perception of math as a subject and why?

The mentioned perceptions of math are also believed to affect the students' study habits, which in turn affect the context in which edtech for math is introduced. This gives rise to the fourth research question:

Q4. What are different kinds of students' study habits regarding math and why?

1.4 Delimitations

The access to students, teachers and the exploration of the four research questions were facilitated through the introduction of one edtech tool for math. The edtech tool provides students with videos of solutions to various exercises. The findings relating to characteristics of the tool are thus less generalizable than the other data collected. The study is focused on the learning rather than the teaching of math. The study besides the literature study is limited to Swedish high schools or rather the three schools visited during the pre-study and the main study. The background is mostly built around Swedish math results and the discussion is focused on Sweden and its educational system despite containing some general applications. Due to the limited time and scope of the study, it has not taken into consideration the political or economic aspects of education and teaching.

1.5 Disposition

This introductory chapter is followed by a theoretical framework, a method chapter, a presentation of the findings, an analysis of the findings, a discussion and a conclusion. The report also encloses an appendix chapter with answers to surveys and some computations.

2. Theoretical Framework

This chapter will explore factors related to performance in math such as motivation and demotivation among various kinds of students. There will be literature presented regarding Sweden as well as different international but relatable publications. The factors are of behavioral, psychological and partially heredity nature. The later part of the literature review concerns edtech for math and previous studies of how the use of different information- or communication technology affects learning both in terms of actual performance and in terms of attitudes towards math. There will be examples of successful implementations as well as discovered barriers to adoption. The term edtech is not just new, it is also broad and refers to many kinds of educational tools. This causes some ambiguity and the reader is encouraged to keep this in mind while reading this chapter about various studies of the use of various technologies. Edtech is typically divided into three main areas (BrainCert Academy, 2015). These are synchcronous and asynchcronous, collaborative learning and linear learning. The tool introduced in this study is a linear tool as the student is passive in the learning process. The exploratory nature of this study allows for a wider view of edtech for math to explore how and when it has been implemented well or not, regardless of which specific tool is referred to.

2.1 Performance in Math

The literature review has revealed the fact that many factors affect performance in math. Furthermore, it has shown that mathematical performance cannot be evaluated using a single measure as stated by Dowker (2004). She stresses the fact that mathematical ability contains many elements and that an individual can be good at certain things within the subject of math while being very challenged at other. It is incorrect to talk about one mathematical capability when overall math requires many. However, the aim of this study is to study how the use of edtech can affect perceived ability rather than actual ability and distinction between different abilities is thus unnecessary.

As with all human capabilities there is an ongoing discussion about whether genetics or environment is most dominant is shaping mathematical ability. Dowker (2004) is convinced that there is an interplay between the two and is hence not denying the fact that there are genetic predispositions. No “math-gene” is mentioned, but according to her studies of the brain there are patterns among the looks of different human brains corresponding to certain math abilities and/or inabilities. On the other hand, a recent study conducted by Sigmundsson et al. (2013) found that in contrast to what it is often said about mathematical skills the hereditary factor of mathematical talent appears rather insignificant compared to practice improving performance. This research is focused on the aspects of performance in math that can be affected through for example practicing and the use of technology and will thus not explore to what extent performance is hereditary or acquired through practice.

2.1.1 Motivational Factors in Math

Performance in math is commonly associated with motivation in math as explored by for example Lao et al. (2017) and You et al. (2015). Lao et al. (2017) explored the relationship between intrinsic and extrinsic motivation, goals and performance in math and found that the presence of goals, preferable intrinsic and extrinsic, lead the students to develop ways of reaching their goals. Students with a high degree of goals were much more likely to develop motivation and internalize it as useful ways of goal attainment than their goal-lacking counterparts. Sigmundsson et al.’s (2013) findings about the importance of practice to

improve performance makes motivation even more important in increasing mathematical performance.

You et al. (2015) found a strong correlation between having a teacher that is perceivably encouraging the students with positive feedback and motivation and perceived independence and ability in Korean middle schools. The study and its findings is plausibly extra relevant to refer to, given the fact that Korean children are continuously found exceptional in math in international comparisons. They are simultaneously low in what You et al. (2015) refer to as "intrinsic motivation" and "self-efficacy". They present a possible explanation to this contradiction to other commonly studied cases, where internal motivation has been found crucial; societal and parental pressure is so high in Korea that the students perform regardless of their inherent motivation. This is believed to be true at least for younger children.

Studies show that intrinsic motivation decreases even more throughout high school which according to You et al. (2015) will eventually have implications on performance. Their study of second-graders also found intrinsic motivation to be a determinant of performance in absence of supportive behavior from the teacher. So, whilst most Korean children are performing very well, despite a likely lack of intrinsic motivation and self-efficacy, there is still a relationship between the factors and accomplishment in cases where the students are not motivated by the teacher. These characteristics serve as substitutes for external motivation perceived to be expressed by the teacher. The finding is logical given the fact that You et al. (2015) also found that support from teachers only indirectly affects accomplishment in math through improvement of intrinsic motivation and self-efficacy. Turner et al. (2004) have studied motivational behavior coming from parents and found that positive attitudes from parents are performance enhancing. Mothers' encouragement was found particularly important by leading the students to expect better result as well as considering math to be essential in their future profession.

Attitudes Towards Math

One aspect seemingly corresponding to motivation and thus performance in math is that of attitudes towards the subject. Math is commonly regarded as something necessary evil (Dowker, 2004) and there are many papers written on topics related to attitudes towards math. Larkin and Jorgensen (2015) made a study of attitudes that indicated that pessimistic feelings of sadness, boredom and anger regarding math are established very early on based on their sample of six-year old's. The concept of poor attitudes as a determinant for lack of motivation and poor performance relates back to Skolverket's (2017) study of Swedish high school students. The Swedish students were among the ones from the participating countries in the 2015 TIMMS study that valued math the least and their overall weak performance could plausibly be explained by the negative attitudes.

Math Anxiety and Math Confidence

Math anxiety and math confidence have been identified throughout this literature review as two relevant concepts affecting performance directly and indirectly through their effect on motivation. Math anxiety appears to be a popular research domain. Dowker (2004) explains how math more than any other subject seems to intimidate people and arise very unpleasant feelings. Math anxiety frequently appears specifically studied in relation to students' performance in math. Ashcraft and Krause (2007) argue that math anxiety not only correlates

with avoidance of math but also poor performance. Meece et al. (1990) on the other hand found no causation between math anxiety and performance in math nor did they find correlations between math anxiety and math related attempts. Maloney and Beilock (2012) provide neurological explanations to weak math performance among students with math anxiety; negative thoughts associated with math processed in the right amygdala regions negatively affect math performance by preventing working memory and numerical processing from functioning ideally.

Numerous studies regarding math performance as a consequence of anxiety or confidence are concerned with the impact of demographics. Socio-economic background, parents' educational background and gender are exploited factors. Dowker (2004) mentions how children of math anxious parents are pre- dispositioned to develop fear of math themselves. This is said to happened as a behavioral transfer where math anxious parents cause math anxiety in their children. The effect is also believed to be multiplied as these parents tend to avoid and/or be unable to help their children with homework in math.

Neuville and Croizet (2007) also explored how the concepts of lack of confidence in math and low expectations from parents, and teachers, lead to lower achievements studied with the gender approach. The findings indicate that math anxiety might be at play as the studied girls only perform worse due to being reminded of their gender at more difficult tasks whereas the perceived gender disadvantage is performance enhancing during simpler exercises. There are other examples of studies where expectations from parents appear to play a role in creating math anxiety amongst girls. Yee and Eccles (1988) discovered that parents were more likely to explain daughters' math achievements with hard work and sons with pure intelligence or aptitude for math. Another interesting study on the subject by Beilock et al. (2010) found that female teachers' math anxiety affects girls' math achievement. The study draws the conclusion that girls in elementary school perform worse at math if they have a female teacher with math anxiety through internalized assumptions about women being inferior at math.

The gender approach is repeatedly used as a way of studying not just the gender aspect itself but the relationships between motivational behavior exerted on the students, their anxiety or confidence and their performance in math. Eccles and Jacobs (1986) studied how students' approaches to math are affected by social aspects, such as expectations, and tried to understand why boys generally outperform girls in math in other performed studies and tend to seek a future in math related professions. They found that parents', teachers' as well as the student's own expectations and potential math anxiety determined their performance. Parents were found to have the greatest impact on the students by influencing their perception of their own capability and the decision whether to pursue studies in mathematics or not. In contrast to the teachers, the parents in this study in general believed in biological differences affecting math performance. The difference in performance between the genders can according to Eccles and Jacobs (1986) entirely be explained by sociological circumstances. The mentioned aspects were found favoring boys' achievements and future in math related subjects.

Despite the indications that math anxiety can worsen performance in math there is no guarantee that confidence correlates with great achievements. According to a study conducted by Mathworks in 2012 (Von Schultz, 2012), when the Swedish math results were

at their lowest, 75 per cent of the Swedish students perceived themselves as being good or very good at math. The majority simultaneously stated that they thought that the average knowledge in math among Swedish students had decreased the last decade.

2.1.2 Other Factors Affecting Performance in Math

Literature regarding explanations to widespread weak performance in math also concerns societal aspects. Swedish teachers that were interviewed in connection to the 2015 TIMSS study said that their major concern was lack of time to provide individual help. More than 70 percent of the fourth-grade teachers and around 60 percent of the eighth-grade teachers perceived this to be the biggest issue (Skolverket, 2015). The Swedish debate is also concerned with lack of time among parents and their children (Johansson, 2016). Today's parents are believed to have less time than previously to help their children with homework while the number of activities outside of school carried out by the children are ever increasing. The implications are according to some that there is an element of inequality among Swedish households. The inequality aspect is potentially escalated as LeFevre et al. (2009), amongst many other related studies, found that exposure to math at an early age significantly affects performance in math when the child starts elementary school. When parents introduce math to their preschool aged children they considerably increase the possibility of the child developing good math skills later by creating a foundation for understanding numbers.

2.2 Studied Effects of Edtech

Kulik and Kulik (1991) relate back to what was mentioned about edtech previously and express the difficulty in measuring the overall usefulness of technology for learning given the vast number of tools available, the differences in course content and level at which they can be applied. They still manage to draw some conclusions about the effect of the introduction of technology. The paper lacks modern data but contains references dating back to the 1960s and 70s such as Feldhusen and Szabo (1969), Jamison et al. (1971) and Thomas (1979) regarding what Kulik and Kulik (1991) call Computer-based instruction (*CBI*). The conclusions drawn about the use of, from today's point of view rather simple, edtech are predominantly promising. Whilst creating a review of the separate reviews Kulik and Kulik (1991) find convincing evidence of the benefits of digital technology in the classroom. Efficiency is measured at a statistical level, showing that the student on average save time thanks to the use of CBI. The studies are also showing that this technology is leastways as efficient as a teacher held introduction meaning that even teachers could save time. There are also references to other equally positive outcomes from studies regarding student performance and attitudes in relation to computers in the classroom. In addition to the obvious flaw of not including newer studies, Kulik and Kulik (1991) point out the fact that the reviews upon which they based their paper and its positive findings were mostly gathered from low-level course content, as the available tools at the time could handle limited complexity. Abovementioned publication from 1991 making use of even older studies is one example of edtech, under different names, having been popular in research for half a century.

There are Swedish studies that show that digital tools have positive implications, e.g. reports from The Swedish Parliament (Riksdagen, 2016) and Skolverket (2017).

The Swedish Parliament presented a report (Riksdagen, 2016) on the digitalization of schools and its impact on quality, results and equivalency. Conclusions from the report were:

- Positive effects in terms of increased engagement, motivation and interest amongst the students, which most likely will lead to improved study results.
- It gives new insights to knowledge in schools, where students themselves produce knowledge instead of consuming it from printed teaching materials. In addition, new abilities and competences might develop through digital tools.
- A new role for the teachers, where focus is displaced from planning education to planning teaching, and from lectures to tutorials. Digital tools themselves do not have an impact, but with the right pedagogic frame it provides positive results.
- Development of competences is needed on all levels to create conditions for digitally supported teaching, for students, teachers and school administrators.

Skolverket (2017) describe how the school has a specific responsibility for the students that for different reasons has difficulties to reach the goals for the education, and that digital tools can be a part of the support needed. Digitals tools can also vary and individualize the teaching for all students. Skolverket (2017) continue that the education shall stimulate the students will to try ideas and put them into action and to solve problems. Problem solving is central in the education and in math the students shall be given the opportunity to develop knowledge about strategies for problem-solving, including modelling of different situations. Since a solution-oriented approach is developed by stimulating creativity, curiousness and self-confidence, digital tools have an important role as support and being a part of the solutions.

There are international studies where digital tools have been used in education. UK's Innovation Foundation found, in their study on the potential of digital education, that technology can be used to effectively support various learning activities in different learning environments, including math (Manches et al., 2012). They explain how there is no right technology to use, but that different technologies can be used to support different forms of learning, either individually or intertwined. For the technology to be used effectively, it must be presented in a way that is accessible for the industry, teachers and the students. Further, the potential of the technologies will only be realized through innovative teaching practices, which may include additional training for teachers to be able to use the technology in new ways.

The study identified opportunities to improve learning through technology listed below:

- Improve assessment - technology that can transform assessment to be more effective, efficient and supportive.
- Upgrade practicing - Practicing should not be spent on simple, unrewarding activity. It is most effective when spent on rich, challenging problems followed by the appropriate feedback.
- Turn the world into a learning place - Technology can easily connect learners and their experiences in a cost-effective way. It can also connect the learners directly with labs, workshops and other supportive settings, which contain expertise. By connecting learners with these settings, they may access tools that are not available at their disposal.
- Make learning more social - Technology can enhance conversation, between learners and teachers, and between learners themselves. Teachers should be given the opportunity to organize participative and performance activity, to transform information into knowledge.

Manches et al. (2012) claim that for a tool to succeed in digital education, it must be tested and developed by putting teachers, students, developers together to work closely on the solution. The technology must be designed and implemented with care and inclusiveness. The main error identified is that developers have not included teachers and their practice into development, and will therefore not benefit the teaching. This way of developing could benefit the industry boost sales by providing clear evidence of effectiveness. It would benefit the teachers who would have access to the best tools for their practice, and finally, benefit the learners.

Pierce and Ball (2009) conducted a study on how technology can support teaching and how it requires the teachers to change their way of teaching to support it. The study identified barriers for implementation of new technology which included; the cost to buy the technology (if needed), which then do not support equal accessibility for all students; the loss of teaching hours which must be allocated to introducing the technology; the will and ability for teachers to change and learn how and when to use a new technology.

Sung et al. (2017) also studied educational technologies effect on performance. They specifically tested what they call mobile-computer-supported collaborative learning: *mCSCL* in a meta-study including a comparison between computers and mobile phones used for learning. The results showed that mobile applications had some benefits to computers such as increased adaptability to the individual, quicker response and features like fast texting. Overall, they found that performance, attitudes and collaboration were positively affected by the use of mCSCL. These benefits were found overrepresented in mathematics as well as science compared to other subjects. The authors use their findings to recommend teachers to let students work together while using the technology similar to the active implementation proposed by Straw et al. (2015).

Li and Ma (2005) talk about the use of CAI as in computer-assisted instruction. They performed a study on students challenged with learning difficulties or disabilities. Their results were mixed, partly promising and partly disappointing. They saw that these students benefitted by increased confidence levels and enjoyment when they did math using CAI. There was also some measured increase in actual performance. No effect was however detected on these students' grades. However, the first mentioned pros lead the research group to remain optimistic about a potential of CAI in this learning context.

Studies have been made about video learning such as by Choi & Johnson (2010). They compared videos to reading and found several factors making the videos superior, such as the students finding it easier to remember the video content and feeling more motivated afterwards.

2.2.1 Studied Effects of Edtech for Math

The National Foundation for Educational Research (NFER) and the UK Innovation Foundation (Nesta) conducted a study on the benefits and challenges of implementing a *flipped learning* approach to mathematics teaching (Straw et al., 2015). In the case study the schools implemented flipped learning through online instructional learning (videos) for homework, so that the students came prepared until the next lesson. Some of the schools also allowed

access to the videos during class. Enablers and barriers to success were identified by interviews, with teachers and students (including pre-study classes), and observations. Students and teachers were asked to answer a survey, prior to the implementation and afterwards.

The introduction of videos freed up time for the teachers to spend on other supporting activities for the students, such as collaborative learning, practicing and applying knowledge and skills and independent and student-led learning. The study identified that the teachers had more time for individualized help and to gain knowledge on how the students preferred to learn. The flipped learning approach contributed to the following benefits in students' attitudes and progress in math:

- Increased confidence
- Increased awareness of one's strengths and weaknesses
- Increased independence
- Increased engagement, enjoyment and satisfaction

The enablers and barriers to a successful implementation found in the study are presented below:

- Access to technology - Access to computers/mobile devices and (adequate) Wi-Fi both at home and in school is crucial
- Identifying appropriate video/digital resources - To which extent the tool matches the curriculum. Resources providing feedback on students' progress can provide useful feedback and be used to plan lessons. Digital resources can also be used for revision and recapping content.
- Homework culture - If the school does not have an existing homework policy with high engagement in homework, the school must institute this before introducing flipped learning. Other alternatives are open access to computers during breaks or enabling students to use the resource during lessons.
- Attitudes and capabilities of students - The attainment level, maturity and ability to work independently should be identified. One should be cautious of introducing activities of high level and thorough explanations to students with a basic level of understanding and less confidence in working individually. Where students are less confident and unfamiliar with taking responsibility, the teachers can consider an introduction of the resource in class, or utilize the knowledge from students who have completed the homework and ask them to lead the start of the lesson.
- Managing the change to flipped learning - Willingness and capacity of teachers to handle change and to be flexible and adaptable according to how the flipped learning is proceeding (this finding is also support by Pierce and Ball, 2009). To which extent the teachers' perceived value in delegating the direct instructional aspects of their role to technology. Flipped learning should be considered as one approach amongst many, where the method must be adapted to the context of the lessons. The resource must be used and changed, so that it fits the learning for the students.

Ruthven and Hennessy (2002) have studied outcomes of the use of various edtech for math in secondary schools. The study aimed to mainly focus on positive aspects of usage and includes teachers' statements and descriptions of their own experiences. The teachers mentioned obtained benefits of having used graph drawing software and other more or less

playful programs. They commonly said that the perception of the students is that they enjoy technology as a welcoming pause from traditional classroom learning. This is in turn said to increase the students' motivation. Motivation was also believed to be bettered as the students could easily make quick adjustment rather than being demotivated by tedious mistakes. Technology of this kind was by some teachers said to remove the frustrating parts of doing math by for example providing instant feedback.

Spradlin et al. (2009) tested actual effects in one case of technology used in math. Some students were exposed to normal lecturing whereas the others were instructed with the aid of computers. They found no difference in performance. This result could be interpreted as an argument to stick to normal teaching or as a reason to make as shift as technology could reproduce the instructions at a much lower cost, depending on the scale of the educational institution. However, the context in which the studied university implemented the computer-based instructions was to increase the amount of college students that passed a certain math course preparing them for university and this was thus not achieved with the help of digital instructions.

2.3 Studies of Math Teachers' Views on Edtech

Pierce and Ball (2009) conducted a quantitative study and let Australian math teachers share their personal beliefs on math and technology. They found that the majority of the 92 secondary school math teachers participating were rather confident in edtech, or at least its ability to enable a better understanding and make learning more entertaining to students. Nevertheless, only slightly more than half of these teachers said that they thought the use of technology could make the students more motivated to increase their knowledge in mathematics. The study also revealed some interesting barriers to implementation of edtech in math. The most significant one being the teachers' fear that the technology itself is too expensive for many or some students causing inequality. One third of the teachers were worried about this. Another finding, with potential effects on how and if teachers will incorporate technology in class, is the fact that one fourth of the participating teachers worried that the use of technology would interfere with the lectures and steal time from compulsory course content. The authors prove that this belief correlates with the perception that there is enough edtech for math used already and that traditional use of pen and paper is ultimately superior. This is interpreted as new technology being viewed as additional work rather than a decrease of workload.

Quillen (2010) concluded that math teachers are affected by math being the subject with the biggest supply of edtech tools. The large number of available tools are said to make the teachers more concerned about making productive use of the ones already available, than developing new technology.

2.4 Studies of Students' Views on Edtech in Math

In 2003 Deaney et al. made a study of secondary school students' opinions on their exposure to edtech, in the study called Information and Communication Technology, *ICT*. Like many other studies they were inclusive in their definition of technology. The students spoke of various types of technology they used for different subjects. Tools including graph drawing calculators, science tools for data storing and usual computers used for simple typing were mentioned. Overall the attitudes exposed through 27 interviews were positive towards edtech

and computers. Listed benefits were students feeling more motivated and interested because of new positive classroom dynamics. One interesting reason for this increase in motivation is that some students would normally be very discouraged by their own messy notes and inability to draw graphs. The students also said that they appreciated the increased level of autonomy they felt while getting exposed to assignments and exercises suitable for their individual level. Despite all good news the students also reveal concerns. One concern was that a school reformation would happen totally replacing teaching with technology. Other negative experiences the students had come from lack of instructions being it in excel or other less specific computer skill. The students did not appreciate when it was up to themselves to figure out how to use these ICT:s.

Vale and Leder (2004) did a similar study on Australian middle school children. Their findings further support the ones obtained from Deaney et al. (2003). They targeted these students' previous experiences of working with computers in math and found that they were predominantly positive. The experiences included the use of spreadsheets, graph drawing programs and the likes. One of the studied classes was also a so-called laptop class, using computers in most subjects. One interesting angle to their positive findings is that boys were significantly more positive about the use of edtech than were girls. The reasons for being positive or skeptical were also different between the genders. The boys said that they appreciated to learn math using computer programs as well as improving their computer skills whereas the girls were not as easily convinced about the benefits of using math software. More girls were also worried that these tools might not benefit their performance or learning.

3. Methodology

This chapter begins to present the research design of the study. It continues to describe why certain methods were chosen, how they were carried out and in what ways data was analyzed. The chapter ends with reflections on the reliability and ethical aspects of the study.

3.1 Research Design

In this report, research design is referred to as the plan of action that links the researchers' assumptions to specific methods (Creswell and Plano Clark, 2017). This section describes how the researchers sought to find methodological fit, how an approach to study the problem evolved and which methods were deemed fit for the study. It ends with a description of the framework that guided the researchers throughout the study.

3.1.1 Methodological Fit

This study takes the form of intermediate theory research, since it uses literature from two different areas, Swedish students' math performance and the effect of edtech, to propose a new construct. This is done according to the suggestions by Edmondson & McManus (2007). A common reason for constructing intermediate theory is when the researchers want to reinvestigate a theory (e.g. is Swedish students' motivation as low as perceived?) and therefore questions prior work in the field as described by Edmondson & McManus (2007). They further state that the confidence and plausibility of the researcher's results, compared to alternative interpretations, is enhanced by a thorough analysis of both quantitative and qualitative data. The purpose of methodological fit is to find internal consistencies between a study's elements i.e. research question/aim, reference to prior work, research design and theoretical contribution (Edmondson & McManus, 2007).

3.1.2 Methods

This section will describe the research approach taken during various parts of the study. A mixed methods approach has been used throughout the study, and the layout of the different methods are described in table 1.

	Approach	
Methods	**Quantitative**	**Qualitative**
Observations		X
First survey	X	
First interview with teachers		X
Second survey	X	
Second interview with teacher		X
Group interviews		X

Table 1 – Different approaches for the methods used throughout the study. Both qualitative, interviews and observations, and quantitative, surveys, methods have been used in the study, resulting in a mixed methods approach.

The choice of conducting this type of research is inspired by various authors. Steckler et al. (1992) argue that qualitative and quantitative methods have strengths that can compensate for the limitations of one another. Mixed methods allow the researcher to make use of the advantages of both methods, which may result in new perspectives, help to generalize and give strength to arguments (Easterby-Smith et al., 2015), provide a better understanding of the problem than if the methods were used separately (Creswell & Plano Clark, 2017) and support to build new constructs (Edmonson & McManus, 2007). According to Bryman & Bell

(2015) and Easterby-Smith et al. (2015), a mixed method approach is useful when there is a knowledge gap, where the researcher lack necessary information. This study was carried out as a single mixed methods study with an exploratory approach, as described by Creswell and Plano Clark (2017). They describe one way of conducting mixed methods research by connecting two sets of data by having one build on the other. This was done by using qualitative methods to explain the quantitative findings; a survey (allowing categorizing/grouping) together with interviews and observations (providing specific insights for each group) as suggested by Steckler et al. (1992).

A quantitative approach is preferred if a researcher is interested in questions such as where, how and what are the differences and relations between two subjects (Patel & Davidson, 2011), which was suitable for the study to see relations between motivation/results in math and the use of a digital tool. The use of a quantitative approach results in a measurement of the data collected and statistical processing in the analysis (Patel & Davidson, 2011). The strength of a quantitative approach is that the data collected usually can generalize an assumption on a larger population based on facts (Steckler et al., 1992). According to this statement, two surveys (described in 3.2.5) were compiled to gather the students' general thoughts in terms of math and their perception of the edtech tool. The quantitative data was collected through the researchers own primary data, since it is more accurate for the intended research as suggested by Easterby-Smith et al. (2015).

A qualitative approach is suitable when the researcher wants a deeper understanding or want to explore certain actors' subjective meanings (Easterby-Smith et al., 2015). For this study, an understanding of the incentives and deterrents to studying among students was desired. Words, text and stories are the basis for qualitative data and usually emerges from the study itself (Patel & Davidson, 2011). Easterby-Smith et al. (2015) state that when collecting qualitative data, the researcher should be engaged with the field of study, since it contributes to understanding actions in social practices, which then increases the importance of access and availability. It was therefore decided to conduct observations (further described in 3.2.4) in the current setting (classroom). Additional interviews (described in 3.2.6) were also conducted, as to strengthen arguments and widen the researchers understanding of the situations in the classroom. The gathering of data can be shown to be costly and time-consuming due to the collection, sorting and analysis of the data (Easterby-Smith et al., 2015). Due to the time constraints of the thesis and the limited accessibility to the classes a few occasions for observations and interviews were chosen, but with an intense recurrence.

3.1.3 Contingency Framework

Edmondson's & McManus' (2007) contingency framework for finding methodological fit (shown in figure 1) was chosen for the study thanks to the possibility of sporadic emergence of data through observations and interviews, which later could provide insights to the planned surveys. Continuous iterations back to the literature were made throughout this study, which is described in detail in 3.2 Data Collection Methods. This corresponds with Edmondson & McManus's (2007) statement that the intended research design might be disrupted (changes

which the researcher cannot affect), resulting in iterations back to the literature or the use of different methods.

The described iterative process made the framework further fitted for the study due to the uncertainty regarding access to the classes causing unavoidable adaptations to schedules, tests and so on. The researchers valued, inspired by Edmondson & McManus (2007), continuous feedback, rethinking and revising throughout the study. The framework was considered as a useful guidance, but as Easterby-Smith et al. (2015) describe; a framework is not meant to restrict the researcher, but to align and guide them through the study in a productive and focused way.

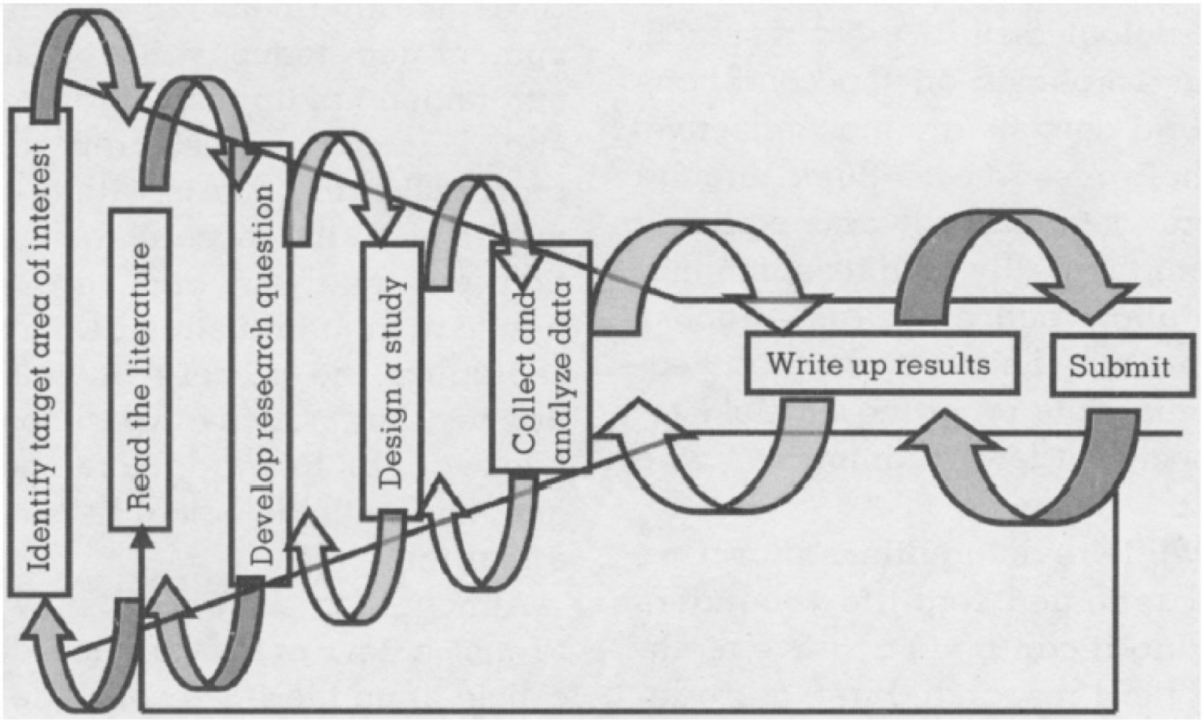

Figure 1 – Contingency framework for finding methodological fit. This framework describes the process of conducting a study in an iterative way, as described by Edmondson & McManus (2007). The framework was found useful in this study by providing guidance.

3.2 Data Collection Methods

This chapter explains how data was collected, and the process throughout the study is presented in figure 2. Before and throughout the collection of data, literature has been consulted. The choice was made to have one class (social science) for a pre-study and two classes (economics and natural science) for the main collection of data. Once the pre-study had been conducted, it gave insight to the main collection of data for the other two classes, in the form of observations, surveys and interviews. The observations in turn gave insight to the first survey, and the first survey gave insight to the first round of interviews. The students were then given access to the tool (videos) for a month, which gave insight to the second survey and the second round of interviews. The mentioned steps lead to an analysis of the collected data described in chapter 5. Table 1 depicts the classes and during which of the methods for collecting data they participated in.

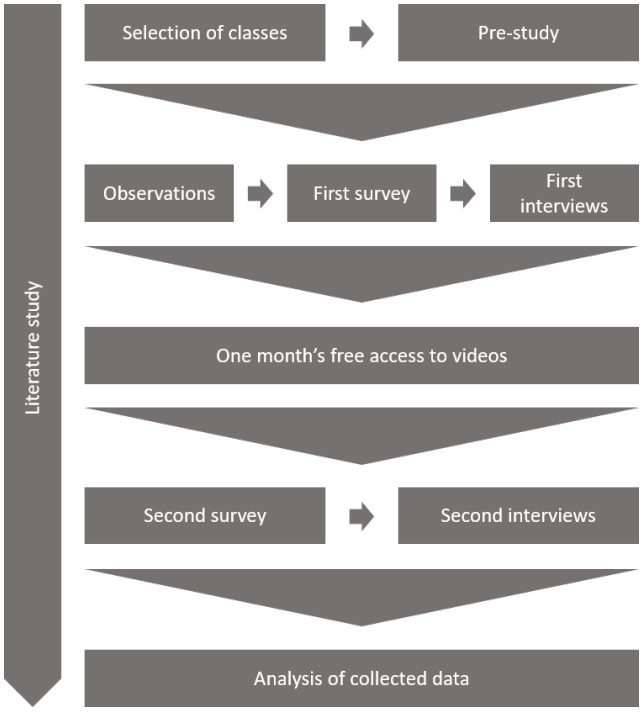

Figure 2 – A presentation of the data collection process. Throughout the study literature was consulted. The methods took place following one another, as they were inspired by the previous method.

Type of class	Pre-study	Observations	First survey	First interview with teachers	Access to tool	Second survey	Group interview with students	Second interview with teacher
Economics	-	X	X	X	X	X	X	X
Natural science	-	X	X	X	X	X	X	-
Social science	X	X	X	-	-	-	-	-

Table 2 – A depiction of the classes participating in the study and during which of the methods they participated. The table shows how the social science class only participated before the introduction of the tool, whereas the other two classes took part in most of the study.

This study has similarities with a study conducted by Straw et al. (2015) on the benefits and challenges of implementing a flipped learning approach to mathematics teaching. The study conducted interviews with both teachers and students, observation in the classes, as well as surveys, prior to the implementation and afterwards. However, in their study the students were required to view videos to come prepared to their next class. In this study, focus was to see how students acted and used a tool when it was not forced upon them and they had the freedom to use it when needed.

3.2.1 Literature Study

The literature study is framed by two areas of research. On one hand there appears to exist some issues regarding math education illustrated by the weakening performance of Swedish students relative to other European countries. On the other hand, there are numerous publications dating back to the late eighties predicting the future importance of technology infused learning.

The literature study was carried out in several steps. Upon establishing contact with the company MathStudy an initial background study took place. The company was partly founded to target Swedish students' weak math performances and this became the first area of literature studied prior to planning this study. Reports regarding recent PISA- and TIMSS results were studied as well as reports from Skolverket. These initial readings contain different explanations for the last decade's daunting math performances among Swedish high school students. The presented explanations suggested further literature regarding psychological aspects such as math anxiety, motivation, stress and the students' perceived importance of math. The TIMSS report from 2015 (Skolverket, 2015) explaining the downward trend also includes a statement from Swedish math teachers saying that there is not enough time to help individual students. All these factors helped initiate the search for literature.

The literature study naturally proceeded with a search for publications regarding edtech in general. Searches using the word edtech was found to be limiting to some extent, explained by the fact that the word is rather new. Despite having been popular in research for a couple of decades, technology infused learning and digitalization appear to be slow inside and outside of the classroom. Reasons for this as well as pros and cons discovered in previous studies became a main part of the theoretical framework. There are many publications to be found on the effect of introduction of computers and technology in the classroom. The focus was on general problems with math education and potential solutions as factors to be studied in relation to technology.

The continued literature study was also influenced by the pre-study performed. This was done to see whether the basic assumption about relevant factors regarding students and math attitudes were accurate enough to proceed in the same direction with the study. The results of this first survey and observations indicated that above mentioned psychological aspects such as math being difficult and boring are of importance for how much time the students are spending studying math. Additional literature was then sought to further understand how various student groups perceive math and how much they study inside and outside of the classroom.

The studied literature was almost exclusively found using Google Scholar and Chalmers' own search tool chalmers.summon. These sites were found useful by allowing the research group to find relevant publications using the related articles feature.

Since this study is performed with a mixed methods approach, there has been a great need to consult extensive literature on various methods. The method required a literature study giving guidelines for how to plan, perform and analyze a mixed methods study, semi-structured interviews, group interviews, observations, surveys as well as qualitative- and quantitative studies in general. Given the fact that the study mostly involved adolescents as respondents

there was a need to make suitable ethical considerations and adapt the method according to literature on how to study non-adults.

3.2.2 Selection of Classes for the Study

This section describes how the selection of classes was carried out and which classes participated in the study. One class of social science students was chosen for the pre-study and two classes, one economics class and one natural science class, for the main study.

The population of interest given the specific edtech tool was Swedish high school students, aged 16 to 19, then studying at what in Sweden is known as Gymnasieskolan. However, there were a few factors limiting the number of schools that would be suitable for the study. The introduced edtech tool was during the study only available for certain math courses, using certain course literature. Some courses were almost fully covered, meaning that there were video solutions to almost every exercise in the book whereas some courses were covered to a lesser extent. This led to a preference for which schools to work with.

Another factor that turned out to be of great importance was individual teachers' interest in the project. The access to teachers that were interested in the project heavily influenced which schools were finally included in the study. Many e-mails were sent to math teachers at Swedish High schools, mainly in the Gothenburg region for logistic reasons. The overall attitude towards students from Chalmers University of Technology and thus willingness to partake in this study was also believed to be the most positive in Chalmers' hometown. This relates to the strategy Bryman and Bell (2015) describe as cluster sampling. The school partaking in the pre-study is a Swedish school located outside of Sweden in Europe.

Difficulties getting access to telephone numbers to teachers were encountered as well as numerous un-responded e-mails and busy teachers. The majority of the sent e-mails never got a reply. There were also unfortunate cases where there were interested teachers using less suitable course literature. The teachers that finally took part in the study offered the research group access to all their classes, but only one class each was found suitable enough given the available video content.

The economics class in Gothenburg was the most suitable class studied. It was using the right book and during the time for the study taking a course that was covered by video material to almost a 100 percent. The social science class, from a Swedish school somewhere in Europe, was using the right literature and the teacher that wanted to be involved had four classes spread over the most appropriate courses. However, there were difficulties in fully incorporating these classes into the study. The teacher used a lot of own made material that the students could choose to work with. The classes were also a bit smaller than in traditional Swedish high school with a higher absence rate, given the fact that most students were on a one-year exchange and had school trips and other activities interfering with the course schedule. The effect of one month's usage of the edtech tool was thereby believed to be small.

This case was however suitable as a pre-study to guide the continued literature study and planning of the study. The students' attitudes towards math as well as their homework habits were believed to be rather independent of which course literature they were mainly using. The students were also suitable as test pilots for the survey. They belonged to the intended

population in terms of age and educational background and their opinions on the survey's intelligibility were believed to be representative.

The access to another class alongside the economics class was decided to be more important than having the full course literature covered for this class. The natural science class chosen was taking a course that was covered by the video material to around 60 percent. This was believed to be enough material to result in useful data. The number of videos corresponded to solution videos for almost every page covered during the study period and hence at least one video per area covered in the book. Given the nature of solution videos as providing a way of thinking and establishing a method they could also have been found useful for related exercises.

The two main classes studied included students from different demographics believed to have different attitudes towards math. The natural science students were about to study a lot of math throughout their high school years. During the study the school was one of the most difficult ones to get accepted to in the Gothenburg region and the students had high grades (interview with the natural science class' teacher). The economics program at the other Gothenburg school was rather difficult to get accepted to, but these students tended to have lower grades in math compared to natural science students (interview with the economic class' teacher). The difference in demographics was intentional given the theoretical framework of the study. The background study revealed issues regarding math concerning students on the entire performance spectrum. The literature review suggested issues of stress, anxiety, as well as lack of motivation or hours studied, prevalent among different categories of students.

3.2.3 Pre-study

The literature study that was conducted provided a general understanding of the current problems within Swedish high school education in math. It was deemed necessary to gain an underlying understanding of the situation in the classes participating in the study. A pre-study was therefore carried out to validate the main data collection. The empirical data obtained from the pre-study: observations and responses to the first survey, was also used as part of the analysis. The data itself is representative given the fact that the observations were carried out the same way as in the main study and that the first survey was only modified slightly, before given to the two classes for the main study.

The survey collected the students' general thoughts in relation to math, and was seen as a way of practice, inspiration and improving the collection of the main data as described by van Teijlingen and Hundley (2001). Through a pilot study, one is exposed to potential problems, such as lack of clarity in the items, which might affect the validity and reliability of the study (van Teijlingen and Hundley, 2001), which proved useful for this study.

In accordance with was is stated by van Teijlingen and Hundley (2001) and Hassan et al. (2006), the pilot study provided an overview of how the main collection of data would work in practice and helped answering questions such as how to distribute the survey, how much time was needed to fill out the survey, if the survey was technically functioning and so on. To ensure the right approach for the collection of data, a test of the survey, in a similar setting as the collection of the main collection of data, was planned beforehand. To ensure the right

conditions for a test, visits to the school and conversations with the responsible teacher were carried out. The conversations gave interesting insights to the current situation in Swedish math and became an inspiration to future interviews and observations. During the visits, initial observations during math classes were conducted to improve the research groups skills and ensure that the planned collection for the main data could be performed. The pilot study helped to fill the research groups knowledge gap in the structure, teaching methods, courses, used material, pupil engagement etc. in present math classes.

The survey was tested on fifteen social science students. After finished filling out the survey, the students were asked to provide feedback on the questions and outline of the survey and if the questions where comprehendible. Law (2016) and Hassan et al. (2006) describe a pilot study as a small-scale marketing research study, which is performed to eliminate eventual problems before full study is undertaken, e.g. the need to change or clarify questions in a survey. The analysis of the answers and feedback from the students lead to an updated survey, which was then presented to the two classes in the main data collection. However, only a minor update was made to the survey allowing these answers to be used as part of the empirical data.

3.2.4 Observations

The purpose of the observations was to gain an understanding of the current situation in the classroom of the studied classes and, if possible, identify different factors affecting the situation. This relate to research questions Q1, Q3 and Q4. The exploration of these research questions about the students' perception of math, their study habits and hence opportunities and challenges in introducing an edtech tool for math, is believed to benefit from observations prior to the introduction of the tool.

To identify factors, some examples inspired by the literature study were prepared and are listed below:

- How the students work
- If the students are asking for help
- How the students ask for help
- The average waiting time until the students receive help from the teacher
- The students' attitudes (towards teacher and classmates)
- The students' engagement/activeness during the lessons
- The students' level of concentration

Three observations with each of the three classes participating in the study were conducted, before the introduction of the edtech tool. The observations were conducted during math classes ranging from 50-120 min. A brief introduction of the research group was made at the first session of each class, as not to distract the students with an unknown presence, and to provide credibility for the study and trust towards the research group as suggested by Easterby-Smith et al. (2015). A low profile was kept during the observations, as not to disturb or interfere with the teaching. The research group took notes during the observations and measured the waiting times (time the students spent waiting for support from the teacher) during the sessions with economics class and natural science class (presented in chapter 4. Empirical Findings). The social science class was deemed too small with fifteen students to receive realistic waiting times. The observations became a foundation for interviews and

surveys throughout the study. This is in line with Simonsen and Kensing (1997) that describe that observations can provide the researcher with an experience of the work observed and have the effect to instantly generate questions for later interviews.

The observations were conducted thanks to the directness and richness they can bring (Easterby-Smith et al., 2015; Simonsen and Kensing, 1997) and for the ability to identify and assess interrelations between variables in the context (Edmonson & McManus, 2007). Simonsen and Kensing (1997) describe that the main purpose of observations is to be present when situations arise and to not have them described in retrospect. The observations were therefore conducted at site with the three classes participating in the study.

3.2.5 Surveys

Two surveys were made and distributed, one before and one after the introduction of the edtech tool. The first survey was pre-tested on the social science class at the Swedish school in Europe. The second survey was similar to the first one and therefore not pre-tested. A total number of 72 students responded to the first survey: 15 from the social science class; 29 from the economics class and; 28 from the natural science class. Only students that responded to the first survey, and hence became part of the study, could respond to the second survey. The total response rate for the first survey was 72/73 present students, meaning 98.6%.

From the economics class 21 students and from the natural science class 28 students, a total of 49, responded to the second survey. The total response rate for the second survey was 49/52 present students, meaning 94.2%. The social science class from the pre-study was excluded from the second survey as they were not given access to the videos during the month the study took place.

The surveys were created through Google forms and given access to digitally through a link shared on the schools' online platforms. The surveys were only handed out once, no reminders were sent to the non-respondents.

The First Survey

The outline of the first survey is described in figure 3. This survey is a part in answering Q3 and Q4 that relate to the students' perceptions and study habits regarding math. This is also believed to contribute to understanding the opportunities and challenges in introducing edtech for math, Q1. To distinguish between different kinds of students some initial questions were asked. To collect data suitable to answer questions about the students' perceptions of math as a subject and their study habits, questions relating to **attitudes** towards and **psychological aspects** regarding math were formulated.

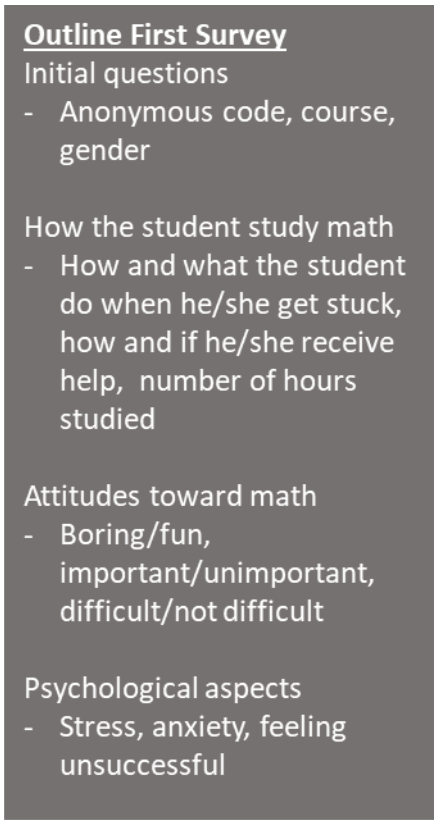

Figure 3 – Outline of the first survey. The picture describes in what order the questions from the survey were asked, and how the different variables were associated.

The characteristics of math *as fun/boring, easy/difficult* and *important/unimportant* were suggested by literature and statements from PISA and TIMSS reports (Skolverket, 2015) regarding Swedish students' performance. These variables were believed to together constitute attitudes towards math. The concept of attitudes was namely believed to be too complex to be measured straightforwardly and hence necessary to divide into questions the students could answer relatively easily. This way of combining a few related factors is sometimes described as "*forming a composite variable to represent the construct*" (Spector, 1992; DeVellis, 2016). DeVellis (2016) suggests that the correlation between these variables is evaluated as to make sure that the made-up construct is reasonably valid. This was done using the computation for Cronbach's alpha in Microsoft Excel. When using responses from the first survey the alpha was computed to 0.77 (Appendix 1). According to the internal consistency scale (Wikipedia, 2018) this is within the higher acceptance span, almost considered a "good consistency" which starts at 0.8. The construct was thereby determined valid and could be analyzed as a single variable. These questions regarding attitudes were also partly inspired by the study *Examining the attitudes and outcomes of students enrolled in a developmental mathematics course at a central Florida community college* by Sisson (2011). The questions finally used for attitudes in the first survey started by "**I think that math is…**" and the students could respond the following on the scale from very boring/difficult/unimportant to lots of fun/very easy/very important.

The literature review such as Dowker (2004), Ashcraft and Krause (2007) and Maloney and Beilock (2012) suggested that psychological factors affect perception of math as a subject as well as study habits. Questions regarding this was therefore included. This is where the changes were made after the survey was pre-tested. During the pre-study stress, anxiety and feeling of uselessness were presented as alternatives in a multiple-choice question. This was later found to be a less suitable option once it was decided that construct validity should be tested for the construct of psychological aspects. The first responses to the first survey from the social science class are therefore analyzed and presented separately in the empirical data. The questions were reformulated before the main study.

It was then decided to have a statement for each of the relevant psychological factors and the students were asked to grade how well they agreed with each statement. Since the middle ground of not agreeing nor agreeing was included as well as the option of "I don't know" these scales were believed to give accurate responses given the tricky nature of the questions. The statements were the following: **math makes me often feel stressed; math makes me often feel anxiety; math makes me often feel unsuccessful**. Since a Likert scale was used the responses from the economics and the natural science class could be used to calculate the construct validity of psychological aspects. The construct validity was computed to 0.84 (Appendix 2).

In addition to above-mentioned questions relating to Q3 and Q4, MathStudy had suggestions about including one question about how many hours the students spend studying math on their own. The company has interacted with students since its start and this has shaped a belief that Swedish students on average study little math outside of the classroom. Other questions focused on MathStudy's tool are the ones targeting if and if so how frequently students get stuck on an exercise. Getting stuck on an exercise is something that the company believes is discouraging for many students affecting their perceptions of math and study habits.

The Second Survey

The outline of the second survey is described in figure 4. This survey is a part in answering research questions Q1 and Q2 that relate to the students' receptions and perceptions of edtech for math and opportunities and challenges when introducing such an edtech tool. The second survey was based on the fact that many students chose to not try the edtech tool, which the researchers knew thanks to statistics of usage from MathStudy's website.

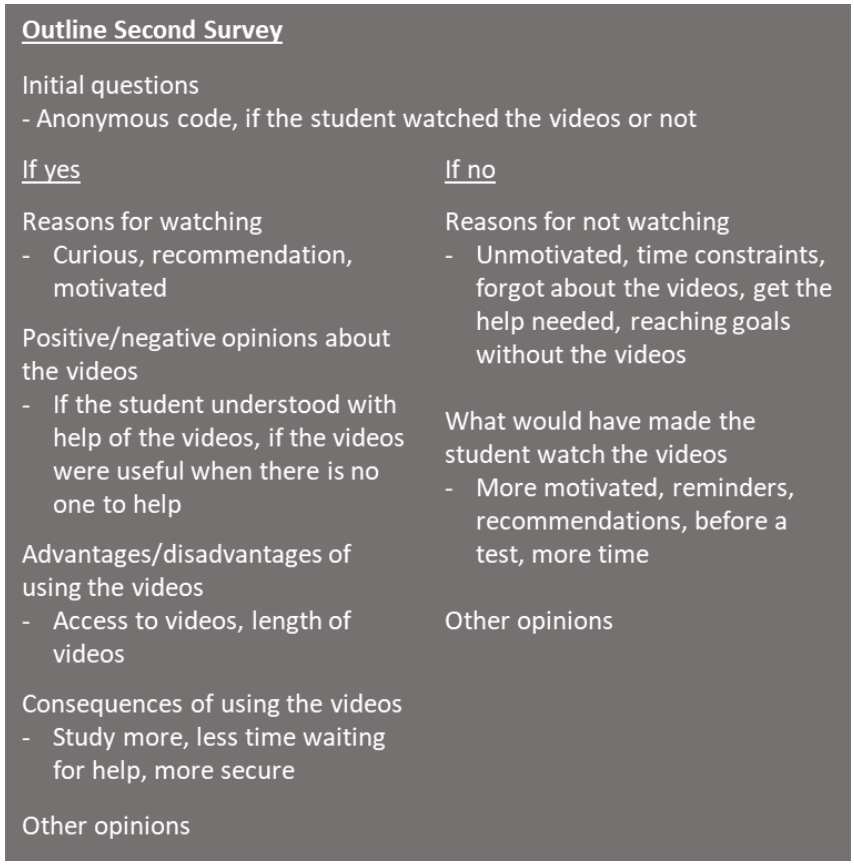

Figure 4 – Outline of the second survey. The picture describes in what order the questions from the survey were asked, and how the different variables were associated. As can be seen, the survey devided the respondents into two groups; those who viewed the videos, and those who did not. Each group were then given specific questions.

The survey was constructed for users and non-users respectively. Very few students had frequent use and there was thus no need to distinguish between frequent and infrequent users.

The users were asked about why they choose to view the videos as well as their opinions about them. Firstly, they were given open questions to capture their own words. Thereafter they were asked to agree to reasons why they viewed the videos and positive and negative aspects and effects of them. Examples: "**I understood with the help from the videos", "It was nice to not have to ask the teacher for help**", "**It was useful when I couldn't ask for help**".

The non-users were given an open question to why they did not view the videos. They were thereafter asked to agree or disagree to statements about why they did not view them such as: "**I felt unmotivated to try the videos**", "**I don't think I can understand with the help from videos**" and **"I prefer asking my teacher to viewing the videos"**. These students were also asked what would have made them view the videos.

Designing the Surveys

Constructing a survey appears to be a science in itself and different sources suggest contradictory approaches. The approach explained by for example Birkett (2017) includes using a response scale with an even number of options to force the respondents to take a stand. No middle ground is provided and the respondents can be categorized into one of two categories. This approach helps avoiding "error of central tendency" but has also been criticized for leading to over agreement when respondents are forced to either agree or disagree as suggested by Birkett (2017). Other literature such as Easterby-Smith et al. (2015) advocate the so-called Likert Scale giving the respondents five options to choose from, the option in the middle being interpreted as not agreeing more with one side than the other. This became the design preferred by the research group. Some nuances of the respondents' answers were believed to be lost if they were to be forced to take a stand. Providing the students with more options and a middle ground was believed to give more accurate and honest answers than if an even option scale would have been used.

It was discussed whether to have a wider odd number scale than the Likert scale. On one hand it could enable detection of smaller effects of the introduced edtech tool on, for example, the student's stress level or hours studied. On the other hand, these potential differences between the answers from the first and second survey could also just be a consequence of time mood and not an actual difference if the scale is wide enough. In addition to this the research group wanted to provide a description of each number on the scale such as "entirely agree" to avoid ambiguity, which becomes difficult with a wider scale. The Likert scale was thus used for questions including an "agreement scale".

There were a few general recommendations the research group adapted such as avoiding double barrel questions as suggested by Easterby-Smith et al. (2015). To use uncomplicated language and keep the questions and statements short as recommended by Larossi (2006) was believed to be extra important given the respondents young age. The research group was also cautious when it came to time references. The students were asked about their attitudes right now or to quantify the number of hours they studied on average every week etc. Questions were intentionally framed so that the respondents did not have to go back in

memory as this could lead to inaccurate answers according to Larossi (2006). Furthermore, the researched group took the advice to evade loaded statements and include the option of "I don't know, as suggested by Larossi (2006).

3.2.6 Interviews

This study neatly fits into the criteria as to when interviews are suitable as described by Easterby-Smith et al. (2015). They describe interviews as a useful tool to comprehend the interviewees' reality to somehow affect it. To understand the teachers and students' responses helps understanding why they might have a certain viewpoint. This section includes a description of the five interviews that were held during the study. All interviews were recorded and transcribed.

There were two interviews held prior to the introduction of the edtech tool, one with the economics class' teacher and one with the natural science class' teacher. Approximately one month later a group of students from each class were interviewed. The teacher of the economics' class was interviewed again at the end of the study. The reason for only interviewing this teacher was that this interview was considered more relevant to the research aim. Only a small fraction of this teachers' students chose to view the videos and the research group was curious as to why the teacher thought this was. This was considered especially interesting as these students had access to solution videos to almost all their exercises. The natural science class on the other hand had a much higher ratio of users while having access to significantly fewer videos. An interview with their teacher was therefore considered unlikely to give any valuable insights. Overall it is considered more interesting to fully explore negative perceptions of math and bad study habits, since these constitute problems potentially addressed by edtech for math. The nonuse of the edtech tool is interesting from a challenge point of view, in Q1.

First Interviews with Teachers

It was considered important to talk to the teachers about their day-to-day experiences of being teachers when they were still unbiased regarding the edtech tool. The first interviews were performed to gain an insight into the individual cases and challenges that might exist related to math in and outside of these classrooms, as to answer Q3 and Q4. This approach has similarities and differences to the methodology used by Straw et al. (2015) and their trials of flipped classroom. While this study involves the teachers through in-depth interviews before and after the introduction of the edtech tool the other study let the teachers fill out a survey on beforehand and conducted interviews when the videos had already been used a while. This difference is natural given the different research aims. While this study wanted to leave the teachers more or less alone during the experiment the one carried out by Straw et al. (2015) included specially educated teachers and enforcement of the new teaching method.

The literature review suggested a number of challenges regarding Swedish high schools. The themes for these early interviews with the two teachers were partly inspired by these theoretical issues, but the interviews were also designed as to allow for new issues and topics to be brought up. The study's exploratory nature made a wide range of topics relevant to the students' perception of math as a subject and their study habits.

The questions were designed according to funnel logic. To avoid steering them into a specific direction the teachers were first asked very unspecific questions such as "**What is it like to be a teacher?**". These questions were then followed up with more specific questions about whether there are any challenges. The research group was still cautious to not mention any specific challenges until the teacher had given a first response. However, when applicable specific questions relating to the literature study were asked. Example of this is the question "**Do the students feel pressured by their parents?**" asked to the natural science teacher.

Given the open approach to the subject, semi-structured interviews appeared to be a suitable method. Fylan (2005) describes semi-structured interviews as particularly suitable when you want to understand different aspects of why things are a certain way. The economics class' teacher implied that there are unique challenges regarding math and got asked to explain why by answering "**Is math a bit special?**" and "**Do you have other subjects?**". The natural science teacher said that the system where students raise their hands to get help does not work in all classes and got asked to clarify why that is the case.

The teachers might feel uneasy being asked about nationwide issues regarding performance and the difficulties associated with being a teacher within a certain school demographic. This is an argument for semi-structured interviews as presented by Fylan (2005). She points out that this method enables a soft approach to touchy topics. To talk to the teachers in person and phrase the follow up questions in a suitable way, explaining the interest in them should have appeared less harsh than if they had received written question. Both teachers were for example asked if they "**Feel that they manage to help all students that need help**" and about their takes on the Swedish PISA and TIMSS results, questions of seemingly sensitive nature.

Both interviews were prepared similarly even if the interviewers learned from the first interview. The second interview was made more structured than the first one. To reduce the amount of unpredictability the research group decided to prepare more specific back-up questions for the second interview These questions were then used to fuel the conversation during the interview, but only to get substantial answers out of the respondent.

Easterby-Smith et al (2015) describe how it is easier said than done to remain neutral and avoid any temptation to add one's own beliefs into the interview situation. This was something that the interviewers experienced while trying to not too actively seek examples of what had been found in the literature review. The semi-structured interview as a method and the funnel logic used helped in making sure that the respondents were first able to associate and respond freely without interruption. To stop taking notes and fully concentrate on listening was also found useful in avoiding this kind of bias.

Second Interview with the Economics Class' Teacher

The second interview with the economics class' teacher aimed at understanding the reasons for the students to not try the edtech tool and the teacher's perception and opinions about edtech for math in general as ways of answering Q1 and Q2.

The interview started targeting the edtech tool by asking the following: "**Now when the students have been given access to these videos why do you think that there aren't more**

students using them?" and "**If we consider these particular videos, what do you think would make the students view them?**"

Questions were also asked as to understand in what sense the teacher thought that struggling students could be helped. "How could the threshold be lowered? and "**So there's not enough time for that at the moment: motivating the students like that?**"

It was considered essential to try and capture the teacher's general belief about edtech for math to be able to put the results in a context. This was done by asking the following questions and more: "**Do you think that there's a need for new technology in school or is there a lot already?**"," **Do you think that technology like that could be useful for some**" and "**So there's a certain interest in these technologies, it could be good, but not always?**".

This way of interviewing the teacher after the implementation is similar to what was done by Straw et al. (2015) where they wanted to find out how the teachers as well as the students had perceived the testing period.

Group Interview with Students

The group interviews were meant to serve as a qualitative complement to the surveys to answer Q1 and Q2. Like the second survey the interviews aimed at exploring the rationalities behind both use and nonuse of the videos. The main reason for performing group interviews was to enable a better understanding of the otherwise quantitative data. By conducting group interviews there was a possibility that the students could help each other reach conclusions about their own preferences and experiences leading to more telling results than the ones found in quantitative studies.

The two group interviews were made with eight students from the economics and natural science classes respectively. Between six and eight people is often suggested as an ideal size for group interviews by for example Rabiee (2004). The teachers were not present. The decision to have group interviews was not heavily inspired by other studies, as most of the other studies revised, such as You et al. (2015), have used surveys or observations to study students in learning situations. Some studies are pure literature studies, some researchers only interview parents of students and some study differences in actual performance when technology is used. There are also examples of video recordings, similar but not identical to group interviews, by the students themselves, such as when Larkin and Jorgensen (2015) studied psychological aspects regarding math.

However, Deaney et al. (2003) exclusively used group interviews with students when they studied the students' opinions about edtech. They performed several interviews throughout one semester, making their study more qualitative. This study is hoping to gain some of the benefits obtained by Deaney et al. (2003) even if it is shorter. By using group interviews, they could capture seemingly honest positive and negative attitudes towards edtech. Straw et al.'s study from 2015 also contains some elements similar to this study's group interviews. They appear to have had casual conversations with the participating students, one or more at a time, after having implemented the flipped classroom method. This seems to have been a suitable way to capture the students perceived benefits of the project. They were also able to understand how the students used the videos.

The students interviewed in this study volunteered to be interviewed. Both groups contained users and non-users. The questions were prepared beforehand with follow up questions. The structure of the interviews mainly mimicked that of the survey. However, the in-person interviews enabled the students to fully explain their opinions and habits. The interview focused on the open questions from the survey as the students could now express themselves freely. These were for example: "**You chose to view the videos, why is that" and "the rest of you that didn't, why is that?**". Follow up questions were asked when applicable such as "**Simply out of curiosity?**" or "**One doesn't want to be the first one to try, is that right?**".

3.3 Analysis of Data

Before entering the phase of data analysis, the data was prepared to facilitate the analysis. Easterby-Smith et al. stress (2015) the importance of preparing data. This meant transcribing interviews, taking notes during the observations and transferring the responses from the surveys to excel sheets. Since a mixed method approach was used it was especially important to have a structured way to place and organize the different kinds of data. Google Drive was used to store all data, documents, drafts and many electronic references during the work process. The different parts of the study were divided into different folders, "method" being one of them. Only the two members of the research group had access to the shared folders.

The qualitative parts of the study; the interviews and the observations were analyzed using the takes on analysis of qualitative data explained by Easterby-Smith et al. (2015) that appeared most suitable for each of them. Among their seven qualitative praxises, content analysis was found the most suitable for interpreting observation data whereas grounded analysis was found the most appropriate for (semi-structured) interview data. The observation data is mainly based on predetermined factors such as attention level, perceived motivation and waiting times.

The content analysis of the observations made use of associated methods suggested by Easterby-Smith et al. (2015). The process began by evaluation of the occurrence of the factors or assumptions suggested by the literature study. These were lack of motivation, lack of time to help all students and potential signs of stress among the students.

The interviews generated data in an exploratory manner. The use of grounded analysis as described by Easterby-Smith et al. (2015) was therefore deemed suitable. This approach made coding of the respondents answers necessary as they were not completely relatable to pre-held beliefs. The answers were coded and associated with one another and/or theory when applicable. The small sample allowed the analysis to be comprehensive by avoiding extensive simplification. Answers that were rare and/or contradictory could be analyzed. A huge emphasis was put on understanding the teachers' and students' reality.

The quantitative parts of the study, meaning the first and the second survey, were analyzed with the help of quantitative measures. The answers to various survey questions were sometimes analyzed based on class as noticeable differences between the classes were found. The second survey was analyzed through displaying the users and non-users' responses respectively.

The answers from the first and second survey could also be related to one another as the students were provided with anonymous codes. This enabled analysis of how students with certain characteristics responded to the introduced tool. Examples of the analyses are the students who did or did not view the videos, which then were traced to the first survey for comparison on various responses e.g. attitudes. Hypothetical relationships deemed interesting were evaluated such as negative psychological aspects among students that do not study outside class and/or have negative attitudes towards math. The answers to each one of the three questions were simply analyzed with the help from the anonymous codes.

Some of the questions responded with Likert-scales were analyzed through correlation analysis. The answers were first made numerical as suggested by Bryman and Bell (2015). Correlations were then tested in Excel. The correlations tested are presented in the empirical findings.

3.4 Reflections on Methodology

In this section the evaluation of the study is discussed to understand the methodological implications, trustworthiness and the quality of the research. Although there are many positive sides to mixed methods, Easterby-Smith et al. (2015) and Bryman and Bell (2015) bring up arguments against a mixed methods study. A mixed methods study is harder to replicate compared to a single method. Further, a researcher should be cautious when conducting a mixed study if they are inexperienced, since the results may include suspect findings. Bryman and Bell (2015) describe implications with the replicability of qualitative research, since it is impossible to freeze a social setting and its circumstances.

The study was carried out together with Swedish students for Swedish math books and is therefore limited to Swedish math education, making it difficult to directly apply in another context. To gain access to the same two classes with the same two teachers might be complicated. However, to perform the same type of study on different classes and different teachers with the same approach is possible. The students that participated in this study are now aware of the research and have used the tool, which make them unfit for a replication of the study. The access to the digital tool might complicate replicability further, since the company will have to allow researchers access to its webpage to provide accounts to students.

The two classes who participated in the main study were from different schools and from different programs, which the researchers deem as necessary measures to represent the most important groups of the population (the largest programs in Swedish high schools). However, there is doubt if all types of students are covered in such a study. Another reflection is whether the time-frame of one month's usage is long enough to obtain all interesting results theoretically possible.

The empirical data for this study consists of observations, interviews and surveys. Since the study was performed together with high school students (individuals who are not of age), one must consider if it can be assumed and expected that the students answer the surveys in an appropriate way. Furthermore, some aspects of the survey questions might be hard for the students to quantify. In terms of interviews, one must consider if three interviews with teachers and two group interviews with students are sufficient to build an assumption. However, the researchers tried not to influence the interviewees responses through the

questioning, as to avoid interview bias, suggested by Easterby-Smith et al. (2015). In terms of observations, one should be aware of the phenomenon called the observer effect (Easterby-Smith et al, 2015), were the observants (in this case students) act differently when they know that they are being watched. The students were not informed that they were being observed during the classes, which might have caused them to act normally. Since two observers were present, they could agree upon what they heard and saw, contributing to the internal reliability in the study, as suggested by Bryman and Bell (2015).

The study has been carefully described as to maintain transparency for other researchers as suggested by Easterby-Smith et al. (2015) and Bryman and Bell (2015). Throughout the study the researchers acted in good faith, as not to let personal values affect the process of and the results of the research in accordance with Bryman and Bell's (2015) recommendation. Sources of bias have been eliminated as far as possible to ensure internal validity in accordance with Easterby-Smith et al. (2015), which contributes to correct results.

3.5 Ethical Considerations

Ethical considerations are always important when the study objects are people, naturally even more so when the study deals with non-adults as stated by Farrell (2005). Using adolescents as respondents and observed objects caused the research group to carefully evaluate the chosen methods. First, a contact was established with each responsible math teacher to explain the process. Early on it was decided that the students should remain anonymous with their responses both regarding their teacher and the research group. It was also irrelevant to the study's aim to be able to identify the students.

Other factors relating to the student's characteristics, such as course and attitudes towards math, were considered important. These factors are of more or less sensitive nature. The psychological factors: stress, anxiety and feeling of being unsuccessful were discussed thoroughly before being incorporated into the survey. The questions were kept at a general level, the students were not asked to quantify their e.g. level of stress or relate their stress, anxiety or bad feelings to specific events, only math in general. The questions about current and target grade are of sensitive nature, but again the anonymity as well as the option to not reply were considered sufficient in preventing any discomfort among the students. Questions of sensitive nature were only included if they were truly relevant to the research aim. Literature suggests that previously held beliefs about children and research is untrue. Rather than being viewed as underdeveloped adults unsuitable for research, children of various ages are believed to be worthy participants sharing experiences and opinions etc. (Farrell, 2005). Given the fact that the adolescents partaking in this study are also almost of age, with ages spanning between 16 and 18, they are believed to understand their participation of the study and the implications of it.

The purpose of the survey as well as the entire master thesis project were explained to the students prior to letting them fill out the survey. It was explained how they were going to be anonymous and how the aim of the research was to help students to study math and how their contribution was very much appreciated. This is one of the benefits normally associated with face-to-face interviews as described by Easterby-Smith et al. (2015). By explaining to the students what the research was used for the research group believes that so called "informed consent" was achieved, as described by Sheffield University (2018). The questions were also

not sensitive in that sense that their parents should have been asked about their participation. The students had the option of not participating at all as well as avoiding responding to any specific question by answering “I don’t know”.

Other ethical aspects that were considered were the students and teachers’ agreement to be recorded while interviewed. Both the interviewed teachers were anonymized. The teachers agreed that it was alright to have information in the report stating what program the students belong to and what admission points were needed to get accepted. There are many schools in Gothenburg with the same demographic which ensures that they remain anonymous.

The performed observations are a bit more problematic from an ethical point of view as they border to what Bryman and Bell (2015) describe as lack of informed consent. The research groups’ true intent of performing the observations was not mentioned at a detailed level to the participants. They were not informed about waiting times being clocked or motivational behavior being observed. This was however considered justified given the fact that the teachers knew the general idea about the project being issues in the classroom and allowed the research group to participate in their classes. If there would have been concerns regarding the specific content of the observations, the teachers had the opportunity to ask questions on beforehand. The nature of the observations is not believed to be of such personal or sensitive nature that complete transparency appeared necessary for ethical reasons. The value of undisturbed observations was valued higher than revealing the true nature of the observations, given the plausible outcome of identifying the real issues in the classroom and thus potentially benefiting the participants.

The observations were also anonymized as no attention was paid to what a specific student did or said. However, there was a big amount of respect associated with being let into the teachers and students’ work environment. It was considered a high priority to consume as little time as possible of the lecture and speed up the process of conducting the survey and provide the students with access to the digital tool. The students as well as the teachers were asked to contact the researchers if they had any questions regarding the project.

Regarding the group interviews the fact that there was a group of students might have affected some students and made them uncomfortable. This was handled by letting participation be not just optional but letting interested students volunteer themselves. When interviewed they were also allowed to not respond if they did not feel like it. The teachers were not informed with what different students said. The students were encouraged to share their honest opinions and told that it did not matter had they not viewed the videos.

This study was deemed to contribute to social benefit (in terms of improved education) and to possibly reduce a societal problem on sight (in terms of declining results and motivation in math). The question of sustainability has therefore been put aside for this study. One could draw farfetched conclusions on that electrical equipment might reduce the use of written material and reduce transportation for students and teachers, but this is a research area considered as a future separate study.

4. Empirical Findings

This chapter is divided into two parts; data that was collected before the introduction of the tool and data that was collected approximately one month later.

4.1 First Collection of Data

The first part of this chapter includes the data that was conducted prior to introducing the tool. It consists of data from observations, data from the first survey and data from interviews with the teachers. The observations were made in the social science class from the pre-study and the economics and natural science classes from the main study. All three classes responded to the first survey and all responses are thus presented here. In appendix 6 all questions from the first survey and the percentages of students given a certain answer are displayed. Interviews were held with the economics class' and natural science class' teachers as their students received access to the edtech tool for one month.

4.1.1 Observations

This section presents empirical findings obtained from observations relevant to Q1, Q3 and Q4. Observations before the introduction of the tool are believed to give some answers about the students' perception of math, their study habits and hence opportunities and challenges in introducing an edtech tool for math. Patterns as well as differences between the different classes were observed. During the three lectures spent with each class, prior to the introduction of the tool, the research group paid special interest in areas identified during the literature review: means of studying, getting help, waiting times and motivational factors. There was however an exploratory element allowing observations unmentioned in the literature.

Layouts of Lectures

The layouts of the lectures were believed to influence the opportunities and challenges in introducing an edtech tool for math to students and teachers. All lectures contained a segment where the teacher held an introduction on a specific topic and showed examples on how to calculate a certain type of exercise. These lecturing parts were of various length and left various amount of time left for the students to do selected exercises on their own. The economics class had some shorter lectures: only 50 minutes combined with long introductions leaving as little as 15 minutes for the students to work on their own. The economics class had three classes of a total of 2:50 hours. The natural science class had four math classes a week spanning between 55 and 120 minutes: totally 5:35 hours a week. The social science class had two classes to a total of 2:20 hours.

Means of Studying and Receiving Help

All students in the economics class were provided with laptops with *GeoGebra*, optional to use in class for calculations and drawing of graphs. There appeared to be an even mixture of economics students studying alone and those discussing with friends. However, a lot of the content in those discussions seemed to be unrelated to math. Students raised their hands while wanting help or asked their friends. When the number of hands in the air became more than a couple the teacher tended to write a list on the board instead. In several cases when the economics students raised their hands and noticed that more than a couple of others were waiting to get help too, they changed their minds and took their hands down. The economics class' teacher encouraged the students to help each other. While the teacher explained

concepts and exercises in the beginning of each class they generally asked students to assist in the solution. Few questions were asked during these introductions.

The studied natural science class was overall individualistic in the way that the students solved exercises. A few examples of collaboration or helping one another were seen, but the majority appeared to work on their own or ask the teacher for help. There was a noticeable difference in how the students asked for help. Some were more verbal when the teacher walked past whereas others were hesitant while raising their hand, sometimes with no help given as a result. However, most students raised their hands with confidence. The natural science students were generally active in asking questions during the teacher's introduction to the lecture. The teacher also encouraged the students to ask for help.

The social science students generally did not ask for help. A few students walked up to the counter or raised their hands. Apart from when working with group exercises, the students rarely asked each other for help. The teacher walked around in the classroom and encouraged the students to ask for help.

Overall students in all cases could use phones and computers and could thus search for solutions and explanations online.

Waiting Times

Waiting times were measured in the normal sized economics and natural science classes to help build a perception of the students' study habits. The obtained waiting times are displayed in table 3. The waiting times were in all cases short enough for all students to receive help. In the studied classed there were several occasions where the teacher encouraged the students to ask for help. In about half of these cases the students did have something they wanted help with. The economic class had an average waiting time of 1:34 minutes and a longest waiting time of 5:58 minutes. The natural science class had an average waiting time of 34 seconds and a longest waiting time of 5:14 minutes.

	Economics	**Natural science**
Number of occasions where students receive help	15	50
Number of occasions where students get instant help	5	29
Longest waiting time before receiving help	00:05:58	00:05:14
Average waiting time before receiving help	00:01:34	00:00:34
Median waiting time before receiving help	00:00:34	00:01:00

Table 3 – Waiting times measured during math classes. As can be seen, the waiting times are generally short, and the students often get instant help.

Motivational Factors

There were many factors identified as motivational, or in most cases, un-motivational behavior. The economics class as well as the social science class were talkative during the time designated to own work. Many group discussions appear to have been about other things than math exercises. There were many students using phones, again seemingly not as study tools. While waiting for help these students seemed to play with their phones or talk to each other. During the pre-study students made statements such as "I hate them", about formulas, "This is like nuclear physics" and "Is it only one lecture left before the test?" revealing

perceived difficulty. In addition, in the natural science class one student exclaimed: “I feel really stupid”, and in the economics class the students expressed the difficulty of a math test they had a couple of weeks earlier. Signs of math being perceived as boring were noted as well; many students in the social science class appeared bored and distracted. One student said, “This is not even fun anymore” to the teacher. Furthermore, the social science class’ teacher mentioned that the students are more interested in exercises when they get told that it is related to the national tests. Many students of these social science students started asking the teacher when the lecture would end ten minutes before the actual end time. Five minutes before end time they tried to leave, and three minutes before it was meant to finish the sound level had increased as to drown the teacher’s voice. This school had separate classes where the students could drop in, work on their own and receive help from the teacher. These classes were during the time of the study only attended by a couple of students. The social science class’ teacher said that they expected the attendance to go up before the national exams.

4.1.2 First Survey

The first survey was conducted to gather data of relevance to Q1, Q3 and Q4. The data contains information about the students' perception of math as a subject, Q3, and their study habits, Q4, which is intended as a basis to also understand the opportunities and challenges in introducing edtech for math, Q1.

The total number of respondents was 72; economics 29, natural science 28 and social science 15. 43 of the respondents were girls, 28 were boys, and one preferred not to answer. The response rate was 98.6 %. The charts are displayed with different colors; economics made blue, natural science green and social science yellow. When applicable the different classes are shown in the same charts to enable comparisons. When comparisons are not applicable, purple charts show all classes combined.

Means and Preferences of Studying Math and Receiving Help in Class

Chart 1 shows the frequency with which students from the different classes get stuck on an exercise in class. The frequencies are displayed class-wise to enable an analysis of the need for additional help, from e.g. technology, in different demographics together with the observations that were performed class-wise.

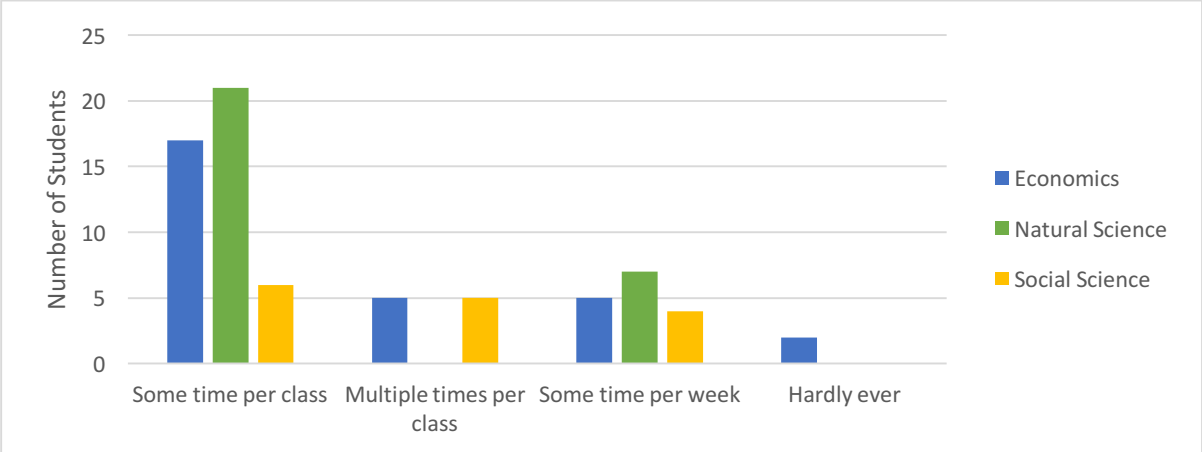

Chart 1 – The average amount of times the students get stuck on an exercise in class. For the three classes, getting stuck some time per class is most common.

Chart 2 displays what the students do when they get stuck on an exercise. This is interesting given the reception of edtech, as this is one of the main situations where it can be used. The answers differed between the classes, which is relevant to research question Q4 about different kinds of students' study habits.

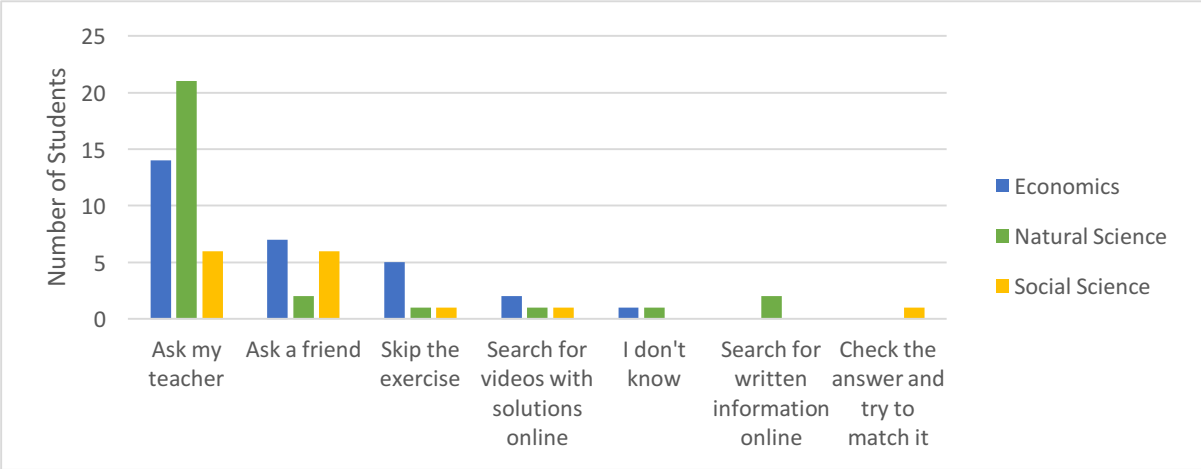

Chart 2 – What the students do when they get stuck on an exercise in class. Overall, it is most common to ask the teacher for help.

Chart 3 shows the students perception about the amount of help that they receive in class. It was irrelevant to distinguish between the three classes as the answers were similar enough. In Analysis of the Empirical Data, Chapter 5, the effect of being satisfied/unsatisfied with the help one receives will be explored.

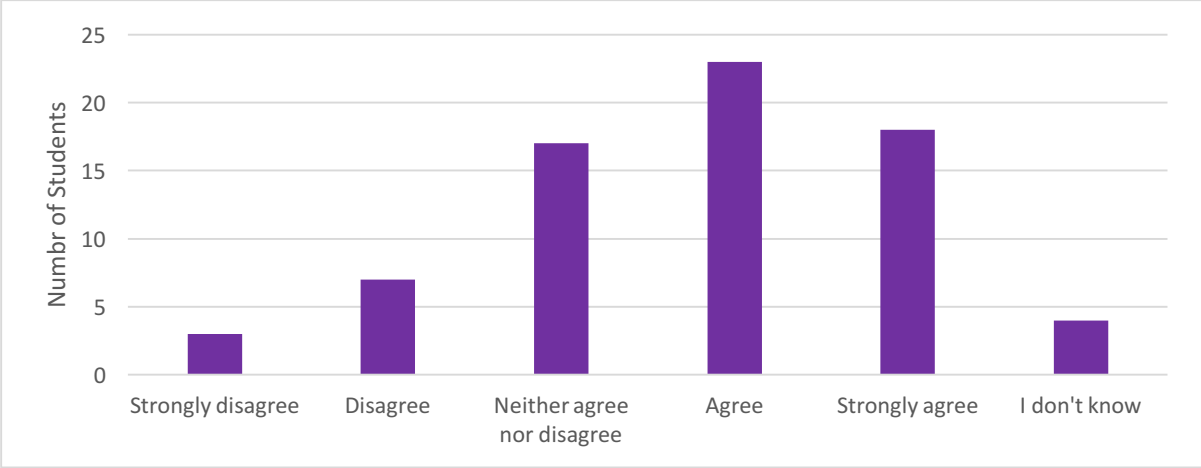

Chart 3 – Whether the students agree to be receiving enough help in class or no. Most students agree or strongly agree to be receiving enough help.

Means and Preferences of Studying Math and Receiving Help Outside Class

Charts 4, 5 and 6 describe how much the students study outside of class, what they do when they get stuck on an exercise then and reasons that they are not studying more outside of class. The answers to these questions varied between the three classes and are thus displayed separately to better answer research question Q3 and Q4.

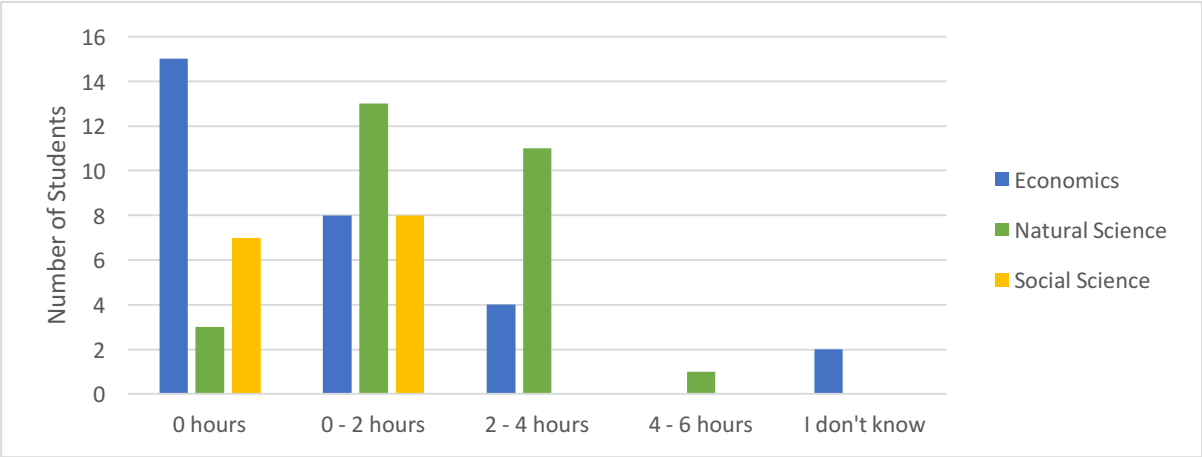

Chart 4 – How much on average the students study outside of class. The majority of the economics and social science students study two hours or less a week. The majority of the natural science students study four hours or less a week.

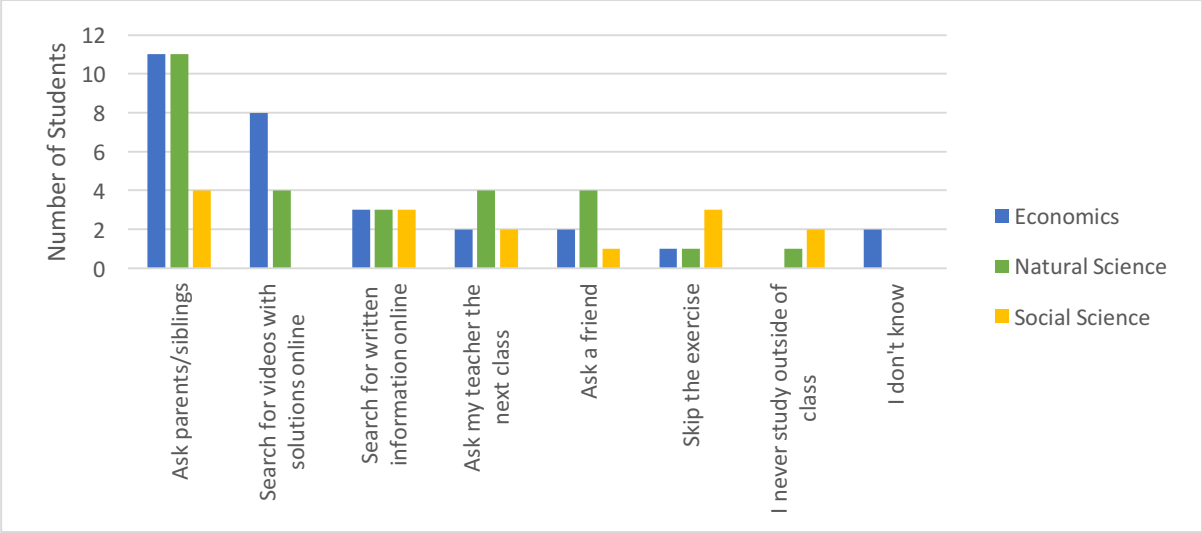

Chart 5 – What the students do when they get stuck on an exercise outside class. The most common reason amongst the students in to ask a parent or a sibling.

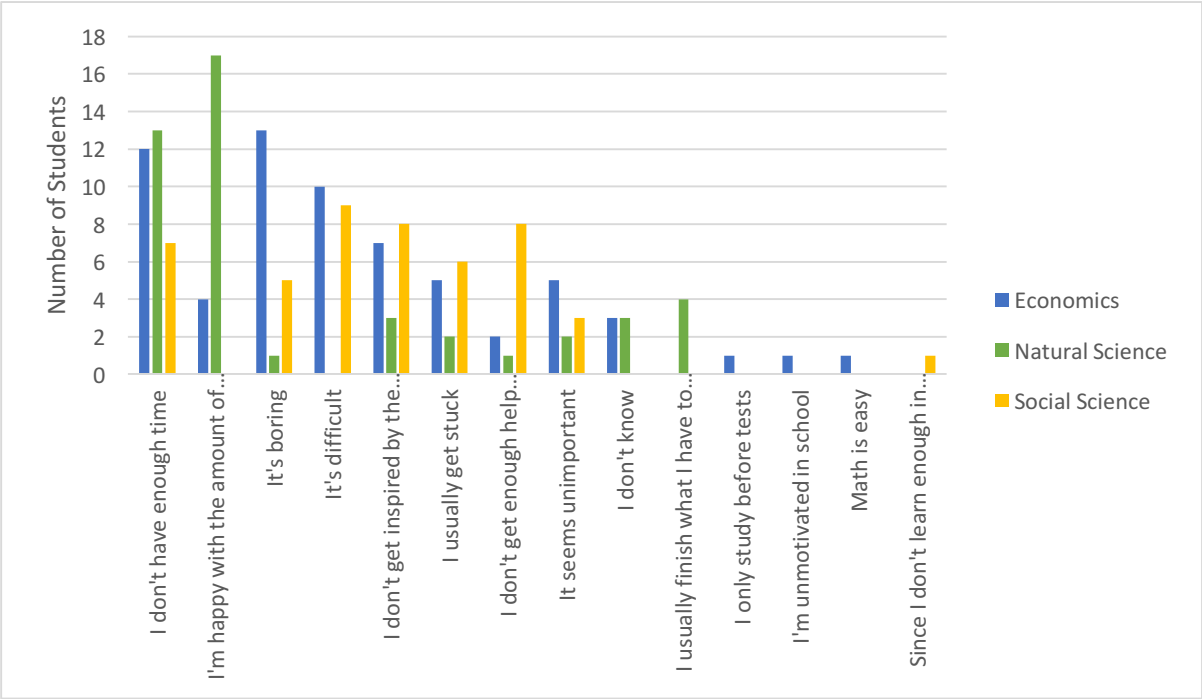

Chart 6 – The reasons the students do not study more outside class. Many students from all three classes agree to not having enough time. The economics students commonly think that math is difficult and boring. The natural science students are commonly happy with the amount that they study. The social science students commonly think that math is difficult, they do not get inspired enough by the lectures and they find it boring.

Attitudes and Psychological Factors Relating to Math

The following tables 4 and 5 describe attitudes towards and psychological factors relevant to math relating to the research question about the students' perception of math, Q3. These measures are constructs created with inputs from three variables respectively. Attitudes consist of the variables: math is fun/boring, math is easy/difficult and math is important/unimportant presented on a Likert scale. The construct psychological aspects are based on disagreement/agreement to the statements: math often causes me anxiety, math often causes me stress and math often makes me feel unsuccessful. The data from the social science class is displayed separately as the relevant variables were modified after the survey was first tested during the pre-study. The questions were designed as multiple-choice questions when the social science class filled out the survey and then as Likert-scales when the economics and natural science classes were given it.

The higher the number for attitudes the more positive attitudes the students have. The lower the number for psychological aspects the more negative psychological aspects the students experience, meaning that a high number is positive in terms of wellbeing regarding math. The scale spans from 1 to 5 with 3 being neutral to the statements. Among all students, 9 out of 72 have negative attitudes to math, that is having a value below 3 for the attitude measure. Math being difficult is the most common contributor to negative attitudes towards math; 31 out of 72 agreed or strongly agreed to math being difficult. Regarding experiencing negative psychological aspects, the total number is 20 out of 72; none of the variables making up the construct stands out as more significant than the others, (Appendix 3 & 4).

Attitudes towards math		Psychological aspects regarding math	
Mean economics class	3,02	Mean economics class	3,29
Mean natural science class	3,79	Mean natural science class	3,65
Mean social science class	2,47	Mean social science class	N/A
Mean all classes	**3,22**	**Mean all classes**	**3,47**
Standard deviation all classes	**0,82**	**Standard deviation all classes**	**1,12**
Min all classes	**1**	**Min all classes**	**1**
Max all classes	**5**	**Max all classes**	**5**

Table 4 – Mean, standard deviation, minimum and maximum value for attitudes towards and psychological aspects regarding math. Overall the mean for attitudes are just above the neutral value. The economics class has almost exactly neutral attitudes, the natural science class is close to having positive attitudes in general and the social science class has worse than neutral attitudes.

Psychological aspects regarding math - Social science class	
When it comes to math I often feel	Number of students
Unsuccessful	10
Anxiety	8
Stressed	8
None of the alternatives	3

Table 5 – Answers from the social science class when asked about psychological aspects. 10/15 of the social science students often feel unsuccessful regarding math, 8/15 have frequent anxiety regarding math and 8/15 often feel stressed.

Performance and Motivational Indicators

Table 6 displays the grades that the students received in their previous math course and the grade that they aim for in their current course. This data was collected to be able to distinguish how determined the students are to improve their grades. Similarly, it also displays students accepting declining grades. This is a measure believed to relate to research question Q3, that is the students' perception of math as a subject.

		Aimed grade					
Grade in previous math course		A	B	C	D	E	I don't know
	A	15	3	2	-	-	-
	B	10	9	4	-	-	-
	C	3	3	6	1	1	-
	D	-	-	2	-	4	1
	E	-	-	1	-	5	-
	I don't know	-	-	1	-	-	-

Table 6 – The grades that the students received in their previous math course compared to the grades that they are aiming for in their current course. Among the students with the lowest grades there is an acceptance for declining grades. This is exemplified by four students that had a D, now aiming for an E while only two of them are aiming at keeping the D. Furthermore, five out of the students with the lowest grade possible (E) are aiming at just keeping the same grade. Only one of these students are aiming at a higher grade. Among the students at the middle of the scale it is more common to aim at keeping a C or lowering the grade from the previous course, than aiming at a higher grade. Only the students with the already high grades, A and B, are commonly aiming at the highest grades. The students that received B:s in their previous math course commonly aim at receiving an A in their current math course.

4.1.3 First Interviews with the Teachers

This section presents the combined interviews of two teachers, the natural science class' teacher and the economics class' teacher. The intention of the interviews was to help answering Q1, Q3 and Q4. Interviews before the introduction of the tool were believed to give

some answers about the students' perception of math, their study habits and hence opportunities and challenges in introducing an edtech tool for math.

Sweden's Results in Math, Not as Bad as Depicted

When discussing Swedish students' results in math, the natural science class' teacher claimed that it is not as bad as depicted:

"*If you think about the publications related to Swedish students' poor performance in math, I think it says more about how you measure, rather than their knowledge. I think the students learn exactly what we want them to learn [...] and there is not much written about the TIMSS-curve, which actually shows that the students have become better than they were. The number of positive publications were very limited, compared to 'PISA results are declining etc.' [...]*"

The natural science class' teacher continued to describe that it became more difficult to receive the highest grade as the rating scale changed eight years ago.

The Economics Students: Only Motivated Towards the End of Semester

The economics class' teacher advocated the importance of the economics students attending the lectures. This teacher described how the economics students are not responsible enough to handle the freedom of recorded lectures, because they will see it as an excuse to not go to lectures. However, many of the economics students want to become accepted at the Business School (Handelshögskolan) in Gothenburg where the admission points are high, so they become focused when the national tests are approaching. The teacher continued: "*The students do not have to understand, they are happy as long as they get the right answer*". A similar comment was made by the natural science class' teacher. This teacher teaches other programs as well and said that for some students the "*specific goal is just passing the course, and eventually graduate."*

The Natural Science Students: Always Motivated

Both teachers describe that students from natural science generally study more and are focused than other students, are self-going and think that math is fun and interesting. The economics class' teacher exemplified: *"[...] natural science classes sit there like lit up candles, waiting for what exciting things that will happen during the lecture*".

Both teachers explained that the natural science students in general have more of a fighting spirit (than other students) and that they are driven. They also both said that the natural science students are more eager to learn math than for example economics and social science students. The natural science class' teacher described how natural science classes are more concerned about grades leading to that the students who study natural science, and are not high-performing, become more stressed than the other students. The natural science class' teacher continued to explain that some of the natural science students do not ask for help, trying to hide the fact that they do not understand from their classmates.

Enough Time to Help Everyone, but Not Everyone Asks for Help

The teachers both stated that how and if the students study at home vary, some students study more, some not at all. Both teachers described that if the students ask for help during class vary as well. The economics class' teacher exemplified: "*There are those who ask for help, and those who just sit and stare*". The natural science class' teacher described that the system of raising one's hand does not always work, which means that the system for helping the students has to be adapted to the particular class. Both teachers stated that, although their

schedules are hectic, they do not experience that they do not have the possibility to help all students during lectures.

Lack of Motivation

When talking about motivation, the economics class' teacher started: "*You must put in work to become good at something, including math*". The economics class' teacher further described how students have to study and keep practicing to come across the threshold, for math to become interesting. The students are aware of the issues often related to math; that it is hard, not fun and important. The students can receive help if they want to, but people are lazy in general which also applies to students, the economics class' teacher continued: "*Whatever helps the students to proceed and push forward is good*". In terms of one student, the economics class' teacher exemplified:

"*I can see that her focus is elsewhere. She just sits and talks to the others. She does not study, and she says it herself, that she does not study. 'I do not have the energy'. And then she tells me that she does not understand. So, I tell her to pick an exercise and we will look at it together, but it never gets that far. The effort must come from her side as well, but she does not take that step. And I can see that she does not have the motivation and the discipline*".

When asked why that is, the teacher responded:

"*I think it relates to what we talked about earlier, what all people have a dose of; this laziness. It is hard [...] It hurts to think. It is painful. [...] And I think it relates to maturity. Finally, you realize that you must deal with your problems. I think some students feel ready to start getting a hold of themselves and in their goals in life after high school and start striving to achieve what they want. Or even find out what they actually want to do*".

High Expectations and Stress

The natural science class' teacher explained how the natural science students are motivated enough to avoid lowering their grades, and that they do not feel good when they do, which leads to stress. The teacher exemplified:

"*At this school we rather work with prevention of stress than worrying about the students not reaching their goals. So, we try to lower the stress level. (As a student) you are supposed to have time for everything; good grades, exercise and eat well, go to parties and even have time to groom your horse. It's absurd*".

When asked if a stress factor exist, the teacher responded:

"*Yes, it does. For many students, it does*".

To the follow-up question if there is also pressure from home, the teacher responded:

"*Sometimes, not always. Sometimes the students put the pressure on themselves. But sometimes there is definitely pressure from home. The parents are expecting too much*".

Positive and Negative Aspects of Digitalization

When asked about positive and negative aspects of the digitalization of schools, the natural science class' teacher answered:

"*The positive side is that it forces schools to become up-to-date. The whole society is becoming digitalized and so should the schools. The negative side I believe, as always when it comes to artefacts in schools, is what you do with it. If you implement something that has no pedagogical value, it becomes strained. You need to think it through, so you do not buy it straight away: 'We should use computers, because I heard that you should.'*"

4.2 Second Collection of Data

The second part of the empirical data is conducted approximately one month after the tool was first introduced in the economics and in the natural science class. The second data collection was mainly designed to serve the research questions about the perception and reception of edtech for math, Q2, and the opportunities and challenges in introducing edtech for math, Q1. This part contains data from the second survey, a second interview with the economics class' teacher and group interviews with the students. The social science class is not included in this part. In appendix 7 all questions from the second survey and the percentages of students given a certain answer are displayed.

4.2.1 Second Survey

The following section contains empirical data from the second survey. The total number of respondents was 49; economics 21, natural science 28: a response rate of 94.2 %. 27 of the respondents were girls and 22 were boys. The classes are displayed with the same colors as before; economics made blue and natural science green. When applicable the different classes are shown in the same charts to enable comparisons between different kinds of students as suggested by Q2, Q3 and Q4. These charts are purple.

Students Who Viewed the Videos

The first part of this chapter will show responses from students who viewed the videos. These responses are answers to how edtech for math is perceived and received, Q2. They also bring some insight into the opportunities and challenges in the introduction of edtech for math. Five economics students, 24 %, and 13 natural science students, 46 %, viewed the videos. Charts 7 – 10 describe different aspects of their viewings. No distinction was made between the two classes as their answers were similar. The most noticeable effects of the viewings were that 50 % of the students felt more confident when getting stuck on an exercise.

Chart 7 shows the students' own answers to why they chose to view the videos whereas chart 8 displays their answers to a multi-choice question about what influenced their decision to view the videos.

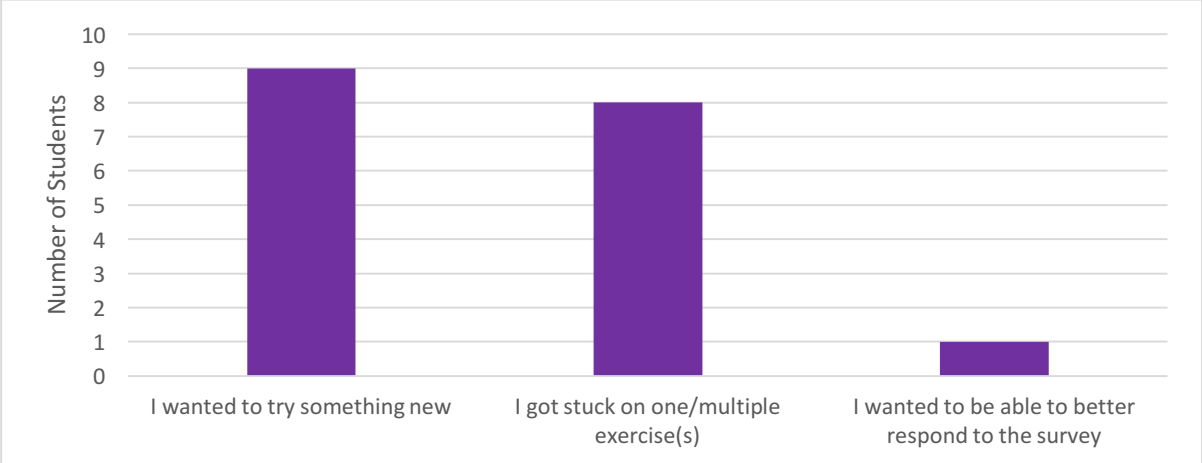

Chart 7 – Main reasons why the students viewed the videos (open question). Most commonly the students who viewed the videos wanted to try something new. They also commonly viewed them as a consequence of getting stuck on an exercise. These are the students' own answers to the open question about what made them view the videos.

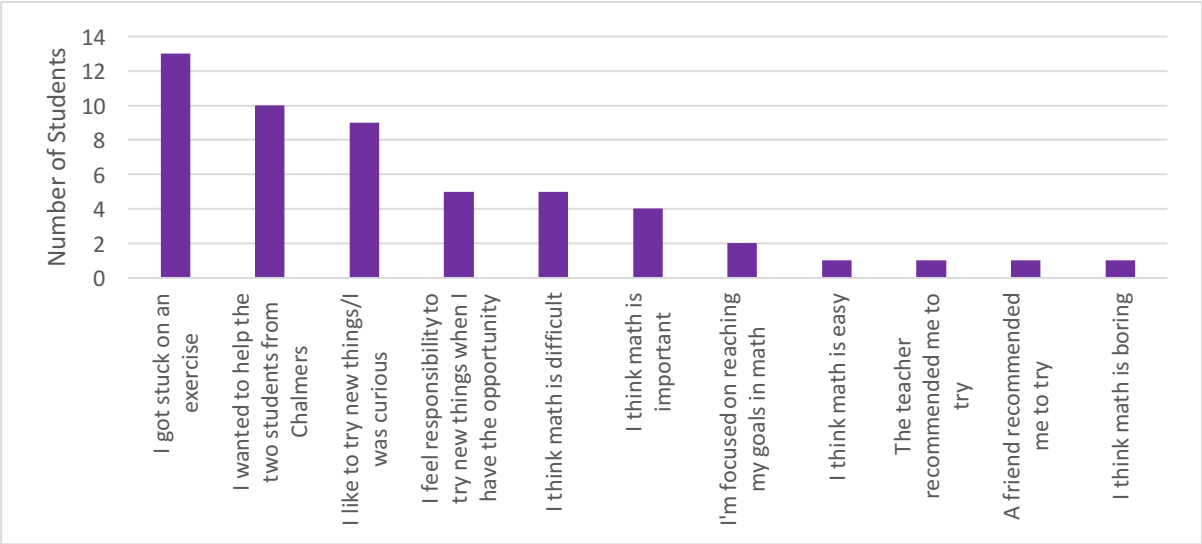

Chart 8 – Reasons why the students viewed the videos. The students who viewed the videos could choose from different reasons why they chose to view the videos. Multiple answers per students were possible. Most commonly the students stated that they got stuck on an exercise, followed by wanting to help the research group and liking to try new things.

When asked about positive aspects about the videos, the students were given the open question: *Were there any positive things about the videos*? The most common answers were: *"they were clear", "well explained"* and *"they provided a solution"*. Other responses were for example that the videos could be applied to other exercises and that pausing was possible. The students were then given the option to choose among different positive aspects of the videos, presented in chart 9.

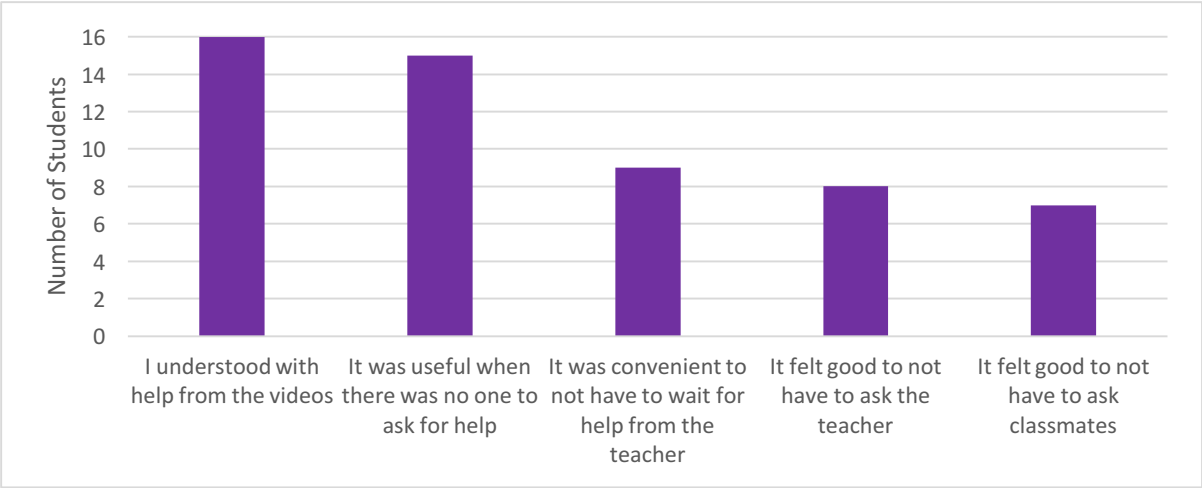

Chart 9 – Positive aspects of the videos. The vast majority who view the videos, 90 %, commonly understood with the help from the videos. More than 80 % thought that it was useful when they had no one to ask for help. Nine out of the 18 students that viewed the videos thought it was convenient to not have to wait for help from the teacher. There were also students appreciating other aspects of not having to ask the teacher or classmates for help.

When given an open question about the negative aspects of the videos, six out of the 18 students did not have anything negative to say about the videos. Common negative aspects mentioned were the lack of solutions for all exercises and the lack of possibility to skip forward. The students were then given the option to choose among different negative aspects of the videos, presented in chart 10.

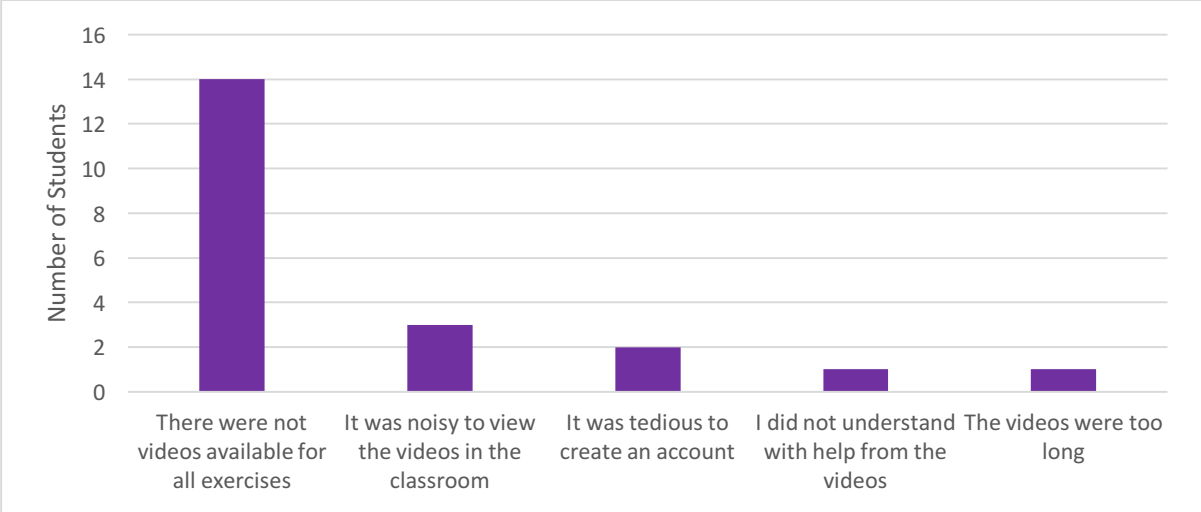

Chart 10 – Negative aspects of the videos. Most commonly the fact that there were not yet videos available for all exercises was considered a negative aspect. This should apply much more to the natural science class than the economics class. However, at least one of the economics students that viewed the videos had the rare problem of lacking a video for a particular exercise in their math book.

Students Who Did Not View the Videos

The following findings relate to different kinds of students' perception and reception of edtech for math, Q2 and their study habits, Q4. Furthermore, the reasons for not viewing the videos relate to opportunities and challenges in introducing edtech for math, Q1. Some of the answers reveal perceptions of math as a subject as well, relating back to Q3. 16 of the economics students, 76 %, and 15 of the natural science students, 54 %, did not view the videos.

When the students were given an open question on why they did not view the videos, the most common answers were as follows:

- I did not have time
- I do not study at home
- I don't have any need for the videos
- I forgot we had access
- I use YouTube instead
- It was difficult to get started e.g. creating an account
- The exercise I wanted to solve didn't exist

The reasons appear to be rather different between the economics and natural science classes. Regarding the multiple- choice question of predetermined reasons for not viewing the videos they are thus displayed separately in chart 11. This is to understand how different kinds of students perceive and receive edtech for math, Q2.

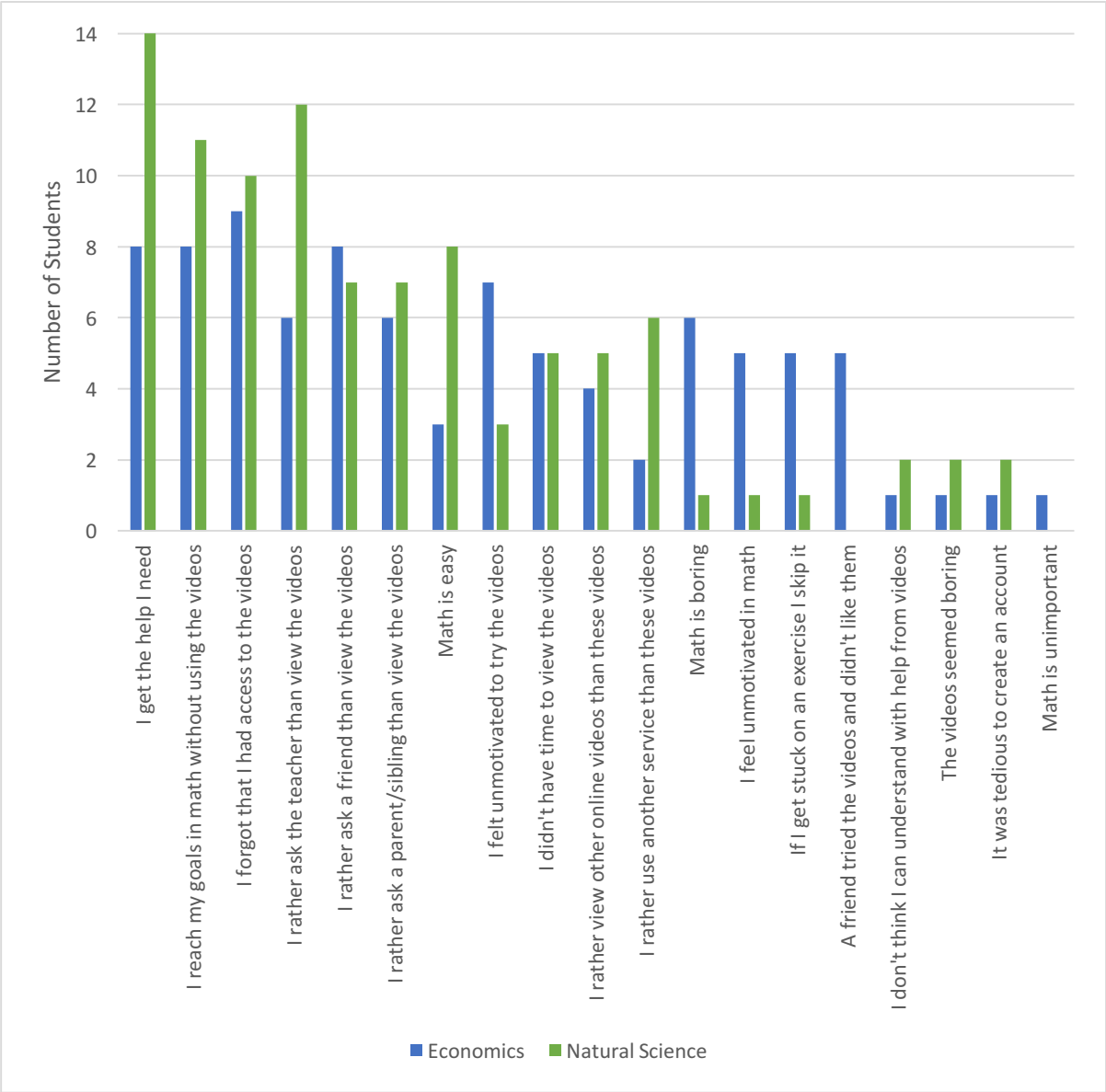

Chart 11 – Reasons why the students did not view the videos. Only half of the economics students that did not view the videos said it was because they already receive the help that they need, same for reaching their goals in math despite using the videos. The natural science students commonly stated that they did not view the videos due to receiving the help that they need and already reaching their goals in math. They also rather ask their teacher for help than view the videos.

When the students got an open question on what would have made them view the videos, the most common answers were as follows:

- If I got stuck, with no one to ask for help
- Before a test/exam
- If it was easier to get started
- If the videos explained better than the teacher

These answers are also reflected in chart 12 were the students were given the option to choose among different reasons for not viewing the videos. The answers were consistent among all student and are thus not displayed class-wise.

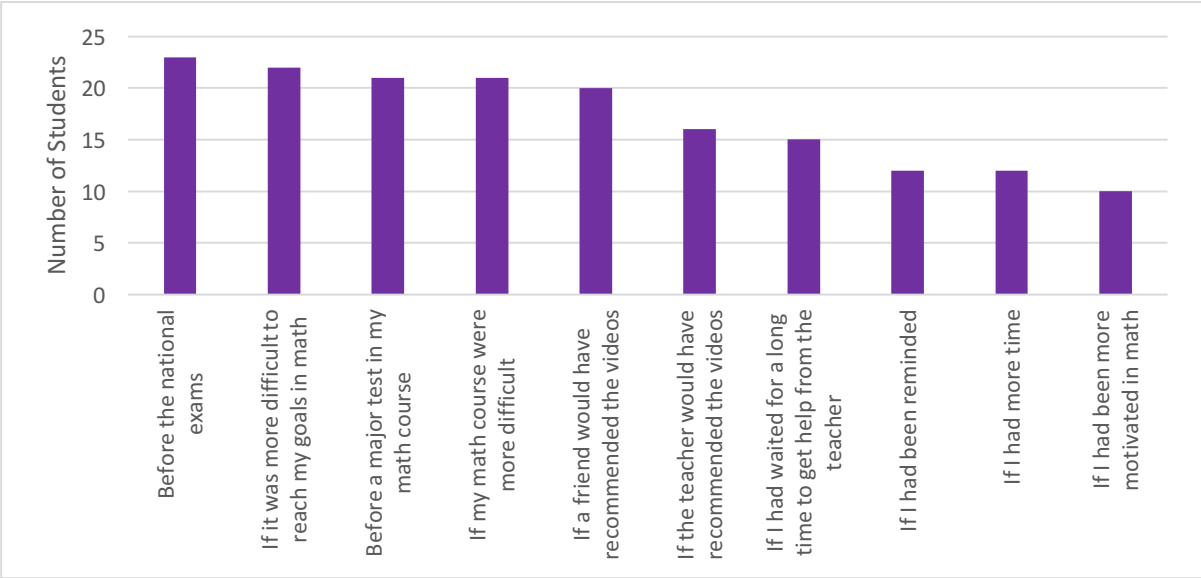

Chart 12 – Reasons which would have made the students view the videos. Many of the students stated that they would be using the videos before the national exams or before another major test in their math course. The students that did not view the videos also commonly believed that they would use them if it were more difficult to reach their goals in math. This relates to viewing the videos if their math course were more difficult, another common answer.

When the students got an open question to provide other thoughts about the videos or learning math, the following answers were given:

- I think it would be good to study math in smaller groups.
- Even though I didn't use the videos I think it's a good idea. I would've used the videos if my teacher didn't upload solutions to difficult exercises.
- I forgot to view them.
- An app would be great.
- Reminders would be useful, but not through emails or texts.
- Everything is already available on YouTube.

4.2.2 Second Interview with the Economics Class' Teacher

The economics class' teacher was interviewed after their students had had access to the videos for approximately one month. Few students had viewed the videos and it was therefore considered relevant to Q1 and Q2 to get their teacher's view on this unenthusiastic reception of edtech for math.

Lack of Support Not a Problem, but Lack of Motivation Is

To the question why they thought that most students did not view the videos that they got access to, the economics class teacher responded: "*I don't think that's (access to material) the sticking point. If they would look around they would see that they are overwhelmed with material and means of receiving help*".

The teacher moved on to mention Youtube an online math coach service called *Mattecoachen* and the fact that "*there are five to six places where the students can go and receive help in math every day*". In addition to this the teacher admitted to uploading solutions online as was brought up by the students during the group interview.

This reasoning is further developed by the teacher who responded the following to the question about what would have made the students view the videos: "*I don't think it's about*

these videos. It's generally about taking action and search for help. Because it's actually that step that is the problem".

The teacher continued the reasoning about the importance of asking for help by saying: "*Yes, exactly. To even request it*". The teacher was asked to explain whether the students generally do not need help or if they cannot be bothered to ask for it and indicated that it is the latter by saying the following: *"As you can see these are no A-students. Well, some are*".

The students' will to improve their grades and performance was not doubted however, "*I think most students do*". Again, the teacher related to what was brought up previously about the supply versus the demand for help in math; "*But you need the energy to take these steps*".

The teacher exemplified this potential lack of such energy among a certain group of students: "*Because I think that there might be a group of maybe around 20 percent, [...] that sort of sit and stare and don't understand, they don't follow. So, there we have the category that doesn't have the energy, that doesn't have the energy to process at the pace with which it comes in*".

This group was believed to doubt themselves and *"feel too stupid*" to ask for help in class. The teacher believed that there is an ability and capacity bar under which students perceive that they cannot "*process and think and hence give up*". According to this teacher it is associated with a significant "amount of work to reach this threshold and then pull oneself together". The only way they believed they as teachers could really help these students, is to spend a lot of time motivating them individually. This is something that there is "*not enough time for*" and something that would not be appreciated by the students that would "*feel really observed*". These students were, given their lack of motivation, said to be "*the ones who would need these kind of videos, so that they can take it in their own pace*".

This hypothetical group was brought up again as the teacher got to respond to the following statement inspired by the group interview: there seems to be a will and they know that the national exams will be difficult, they are prepared for that as the other classes have warned them, and they somehow want to increase their achievements, but something is stopping them? The teacher responded: "*When it becomes too much, one rather sits down and rest. They don't know where to start and now I'm talking about one, what I think, third of the class. I don't think they are more than that."*

Students Need Structure

The teacher said that 25 years of working as a teacher has taught them that students want structure. After having tried creative ways of teaching, including games, to transfer the idea of math being fun they came to the realization that "*the understanding after that type of lectures is not that great*".

Instead "*simple and extremely dull practice is what works. That is the best option. Leave the solutions on the white board so that the students can see the structure and see what it looks like. Because I've seen that many students sit and watch the board over and over again to see how did the teacher solve it? And then they have to do it on their own three to four times*". It was said to be important that the students feel "*yes, I got the right answer. That affirmation. And as you can see there are a lot of them that don't work during the lectures*". The reason for

this was believed to sometimes be an escape because "*It is tough to be in a room where the lecture is about math when you think that math is difficult. Maybe you want to escape into your phone and take it a little bit at your own pace*".

The Ones Who Need Support the Most are the Least Likely to Request It

The current course being significantly tougher than the previous one "*this is when it begins, Math 1B only consisted of everyday math*" was said to be the explanation to the abovementioned threshold. "*Now with x and y and algebra it gets super tough for a certain amount of the students*".

This was then put in relation to the videos and other tools, as the teacher was asked if the ones who would need them the most are the ones who are the least willing to take that step. The response was as follows: "*Well, I don't know how often they search for help, but the little I've asked them about it and dug into it, they don't appear to be looking for help themselves that much*".

Regarding who the videos would be most suitable for the teacher said the following: "*Well I think that it could be suitable both for the ones who are strong and weak in math. But it is necessary for them to have the energy to take this step*".

The teacher did not know if the students perceived viewing the videos as tedious but believed that:
"*It somehow would suit the ones who have this, what should we call it, this inner drive somehow, the ones who don't get discouraged by not having the energy, but that still have the energy to process this kind of information*".
On who they can be the previous argument was elaborated as follows:
"On one hand they can be the ones who are actually weak and that are happy to receive help. Maybe not so ... I think it is a smaller percentage of them that would take the step. But then we have a group in the middle. There might be many there. Now I'm thinking a bit out loud here. And the ones who are skilled might not feel that they need help, more than on a few difficult exercises. It is then worth its weight in gold to go in and have a look then. These students I think are very motivated to go in and have a look to see: how is this C- level exercise solved? That is the higher level".

Edtech Hype Distracts from the Mission to Teach Math

The teacher stressed the importance of distinguishing between different kinds of technology used, regarding math. "*It is a little bit like asking whether TV is good or not. It depends on which programs you are watching*". The following was added:
"*I think one should distinguish between these because, well technology… GeoGebra as well as a calculator are digital tools. Then there are different kinds of Geogebra so regarding technology I think sort of like one bubble is digital tools. Then there's another bubble that is media, a little YouTube, then there's another bubble consisting of videos and digital solutions either written or digital. There are different items there*".

The concept of digitalization in school was perceived by the teacher as vague: "*Sometimes I wonder if people themselves know what they're talking about. Especially the ones that don't work in or have any contact with school*". The teacher added: "*And I can also say as teachers,*

we're a bit overwhelmed with this kind of digital platforms that go through us and that are trying to sell. It's a plentitude actually. So, I think that there are many that sort of want to get on the train and deliver their particular service."

The teacher said that their mission is to teach the students math and regarding the big supply of digital platforms, in addition to the video tool introduced, that:
"This is not what I want. I don't feel any need for it. I have my book and we have GeoGebra and we have this, the video tool, the students have many videos so if one should be cynical that's how I feel. I don't feel: wow, finally! We have everything already".

Another potential downside of the use of technology in the classroom was brought up concerning the laptops that the students are provided with. They were used to respond to the survey used in this study, but as the teacher said: "*after that, they were still up, and I can honestly say that I don't know what they were doing with them*".

4.2.3 Group Interviews with Students

This sub-section presents group interviews with students from the economics program and the natural science program respectively. The group interviews were held with the intention to answer research questions Q1 and Q2 about opportunities and challenges in introducing an edtech tool for math and the perception and reception of edtech for math.

Economics Students

This section presents empirical data from the interview with eight economics students after they had had access to the video tool for approximately one month.

Positive to New Means of Studying Math, But Someone Else Needs to Try First

One student explained why they viewed one video as: "*I don't know. We had been given these accounts so I viewed one video to see what it was kind of. It was mostly like that. "*
It was not to be kind to the research group: "*No, it was actually to see if it was something good that I could use maybe. It was mostly like that. So, during class I viewed one video. "*
Another student agreed: "*I did the same thing. I went in to check when we got them, but apart from that I haven't had a look.*" Another student said "*and I watched at home because I was like, I don't understand. And then I thought it was worth it to have a look so I viewed some videos*".

Four of the interviewed students said that they are positive to new things regarding learning, which could be exemplified by the following quotes:
"*It is always fun with something new. It could always be better*". "*Yes, I kind of feel that if people say that it works super well, then you too want to check it out to see if you could get something out of it, but apart from that I would not have done it myself*".
This latter statement was a common trait among the students who were laughing agreeably when they got asked if they do not want to be the first one to try something new. They referred to the need of someone else being the "*risk taker*".

No Perceived Need to View the Videos in and Outside of Class

Most of the interviewed students that had not viewed the videos agreed to the reason:
"*I didn't feel a need for it*". A reason for this was then said to be:

"*Well I don't do so much math in general, mostly in class, and then I ask the teacher because it's easier to just raise the hand*". To ask the teacher for help was further said to be a common way of getting help as well as asking people that are sitting next to oneself. Regarding receiving help from the teacher and whether it is time efficient or not, the following opinion was expressed:
"*It depends. If there are many people that want help at the same time... But we are sort of a smaller class now. We have divided the classes. We are five math classes from four classes, so we are fewer now and then it works rather well normally.*"

Another student agreed and said: "*Yes, you get help almost immediately*".
However, one student expressed the following opinion:
"*It's more that, well sometimes, this is my opinion: I don't know what the rest of you think but since the teacher wants to help everyone it sometimes happens that they help you quite quickly. When maybe you actually want a long explanation sort of. But this doesn't really affect you. It's not actually bad*".
The student was asked to explain this further by answering whether this means that they do not understand then:
"*Well, no it's more that sometimes maybe it'd been nice to get help for a bit longer. But you do understand that the teacher wants to help others too and they don't leave if you haven't understood.*"

The conversation was steered into what the students do when they get stuck on an exercise outside of class. This had changed recently as they "*previously didn't have many options, but now the teacher has started to upload a lot of solutions to their school platform.*"
The students were asked if it is difficult to reach their personal goals in math and gave various statements, all showing that the current math course is perceived to be more difficult than the previous one. "*More difficult than in year one? Yes, much more*". "*In year one it was mostly repetition*". "*Year one was almost easier than ninth grade (in elementary school).*"

Math Is Important, but Difficult

This sudden increase of difficulty was exemplified with what the students have been told about the forthcoming national exams by the students who took them last year:
"*The national exams will be difficult I think (the other students agree). You only hear about all the students that got F:s. It's the only thing you've heard".*
The students then got asked how they feel given this and said that it feels "*tough, maybe*". They also said that they "*accept the situation*" rather than studying more "*it almost becomes less*". To the question if the stress they feel makes them look for other means of help now, one replied as follows: "*No you don't*" to the others' laughter. One student admitted being very stressed when a test is approaching and "*formulas you thought you understood don't work and there are exceptions*".

The interview then proceeded to the importance of math. Many of the interviewed students agreed to the statement that math is important. When they got asked when and where it is important the responses were related to the future rather than their current everyday lives. One students said: "*More important if you want to study at university and for the jobs later on. Yes, sort of only.*" Another student agreed: "*Yes, only if you want to study later on I'd say spontaneously.*"

Use of Written Solutions and YouTube While Studying Outside of Class

The students were then asked about their habits when they study outside of class. Generally, they said that they use above mentioned written solutions made by the teacher, but some of them said that they have tried other means as well. A couple of them said that they have used YouTube, as exemplified by the following quote: "*I usually also, on YouTube there's a lot where they repeat, provide summaries of the entire chapter and so on.*" Some benefits: "*they are very pedagogical and thorough and you follow step by step*" as well as cons: "*sometimes it's difficult to find the right exercise*" were mentioned.

The Tool Would be a Last-Minute Solution If There Was No One to Ask

Regarding the videos accessed by the tool some positive and negative aspects were mentioned such as: "*Well, I think he (the voice and hand in the videos) was good. He was very clear and so on*". However, something this student was very bothered with was when a mistake was made and corrected as this was perceived as confusing and made the student "*unable to follow*".

When asked about what would make them use the videos and how it compares to asking the teacher the following was said: "*Well if you're at home then I think it's good" "If you ask the teacher, they probably do the same as in the video but you can ask follow up questions then*". The students said that they would use videos more prior to tests and agreed to it being a last-minute solution. The quotes "*Yes, when you study before a test or the national exams or something and it is only days left and you have no one to ask, then you have to take the step and view them*" and "*as soon as you get the need for it without having anyone to ask*" are examples of this. As well as: "Help*, I don't understand this and it's not in the book, it's not in.., I can't ask anyone or anything*".

The Importance of Habits and Having New Technology Explained

The power of habits was also brought up as one student said:
"*I haven't thought about it. Since it's something we haven't done before you forget about it. Then it's more of a habit to go in and check YouTube instead*".

When talking about new technology and digital tools, (with the laptops and Geogebra in mind) the students thought that it is important that someone introduces the software and explains how it works. The following was said: "*Yes, yes I think so. It is probably possible to figure out by yourself, but it probably takes way more time*". The students were also asked if they perceive these videos and the likes as something helpful or just more work and responded that "*It helps. You don't have to do it yourself.". "You don't have to do the unnecessary steps yourself*."

They were also asked about their general attitudes to the use of technology while studying math and other subjects and the consensus is summarized by the following responses: "*Well if it really is easier then; yes*." *"If there exists a better system that makes it more fun"* and *"Yes, if it'd really worked then you would obviously use it.*"

The students mentioned some desires regarding digital tools, especially videos such as them explaining "so that one understands" but also not "*containing unnecessary explanations*" and

thus being ideally "*individualized*". Despite these preferences, the students understood that this would be "*impossible of course*". The conversation continued to be about having a private tutor or namely a grandmother in this case which was perceived as "*very helpful*". The main reason for this was said to be that having someone to help you individually constitutes: "*a safety net while you're working*" so that "*you don't sit for two hours and you've misunderstood everything*".

The students were also asked about the importance of the teacher in introducing new tools for the laptops as one example in addition to the videos being one. One response summing up the general opinion was: "*Well, if we've used it during class and it'd been good then you'd continued to use it when you study on your own*". One student shared their experience of the videos and suggested that they had been more similar to articles on Wikipedia where "*you search for one thing and then you'll find links to topics you might not know about and for more difficult parts of math that you might want to immerse in.*"

Natural Science Students

This section presents empirical data from the interview with eight natural science students after they had had access to the video tool for approximately one month.

Getting Stuck on An Exercise - Main Reason to View the Videos

During the interview, the students explained that they usually ask their teacher during the class if they need help. The majority said that they do not have to wait long to get help from their teacher. The students who have viewed the videos agreed that reasons for trying them were to see if they were useful, or because they got stuck on an exercise with no one to consult. The students who viewed more than one video agreed that the main reason for continuing viewing was also that they got stuck on an exercise. The majority believed that videos, as a mean of help, could support them in their studies, especially when there is no one around to ask for help: "*When you sit at home and do not understand and get stuck, and you cannot proceed even if you check the answer*".

Used to YouTube

One way of finding solutions is to search for it on Google and find a written solution. The students continued to describe that they usually use YouTube to assist them in their studies, both for exercises and general explanations. However, as one student said: "*It can be difficult to find the exact exercise on YouTube.*" YouTube is also the reason why some of the students have not viewed the videos. One student explained as follows: "*That is why I have not viewed the videos, because it is all on YouTube. It feels more accessible and simple. You are used to their platform.*"

Flawless Solution Needed for Conversion from YouTube

When discussing the ease of use on YouTube one student noted:
"*One reason for choosing this (the videos provided) over YouTube, is that when you use YouTube it is easy to get distracted and start looking at other videos. In this solution you have everything in one place and only these videos.*"
The students continued to agree that what would make them convert to using another tool than YouTube would be if they could be provided with something more accessible, e.g. an app. Some students added that they forgot about their access to the videos.

In terms of feedback for the videos, there were both positive and negative aspects. Most of the students thought the videos were well explained and thorough, but it was also noted that: "*It felt like there were more videos with easy exercises than videos with more difficult exercises. The ones you needed most help with were not accessible*". Some of the students said that they do not think it is difficult to reach their goals in math, but most of them said that they want to improve.

5. Analysis of the Empirical Findings

This chapter analyses the empirical data in ways that serve the aim of the study. To evaluate the opportunities and challenges in introducing an edtech tool for math to students and teachers, their perception and reception of edtech for math was studied through the introduction of such a tool. Their general perceptions of edtech for math were captured through the second survey, group interviews with students and the second interview with the economics class' teacher. The first part of the data collection; observations, the first interviews with the teachers and the first survey, gathered data to be used in answering the research questions about different kinds of students' perceptions of math and their study habits. The empirical data obtained will be combined to seek answers to the four research questions.

Regarding *different kinds of students* as referred to in Q2, Q3 and Q4, categorization was made according to various factors found relevant. The empirical data has it that students within a class are consistent in their perception of math and their study habits, whereas the differences between the classes are significant in these areas. This finding made class a relevant factor in answering Q3 and Q4. Regarding perception and reception of edtech for math as well as the opportunities and challenges in introducing it, class appears to be a less dominant factor. Instead it was proven relevant to divide the students into users and non-users. By examining characteristics and preferences among the students that viewed the videos and the ones who did not, valuable insights about edtech for math were gained relating to Q1 and Q2. Another group was identified as relevant to the opportunities and challenges: the students that do not study outside of class. The cross-section between this large group and the non-users was deemed especially interesting as a manifestation of the difficulties with math education in general and the introduction of edtech tools for math in particular.

The literature review also helped shaping the analysis through the suggestion of relationships between the variables: attitudes towards math, psychological aspects regarding math, motivation and gender differences. The analysis therefore contains an exploration of these assumed correlations, all of which relate to different students' perceptions of math and study habits. Furthermore, how having/not having access to enough help in math affect attitudes was studied, since this is where the edtech tool's intended purpose comes to play.

5.1 Students Who Viewed the Videos

By understanding what made the students use the edtech tool, it is believed that one can increase the understanding of specifically opportunities in introducing an edtech tool for math.

The users' main reason for viewing the videos was that they got stuck on an exercise. This corresponds with the intended use of the tool and is hence not surprising. The users' other characteristics might reveal more about what makes someone a user of edtech for math and hence opportunities in introducing such tools. The following section combines findings about the users to identify any common denominators, distinguishing the users from the rest of the students.

The users study more than the average in this study. This is obtained from comparing the users in chart 13 to the values displayed in chart 4. However, this can be explained by the fact that 13 out of 18 users are natural science students. Furthermore, 9 out of 18 users stated that

they are happy with the number of hours they study outside of class. The users are satisfied with the amount of help they receive in class. None of them stated that they disagree to be receiving enough help. This is interpreted as lack of help in class not being an underlying reason for viewing the videos.

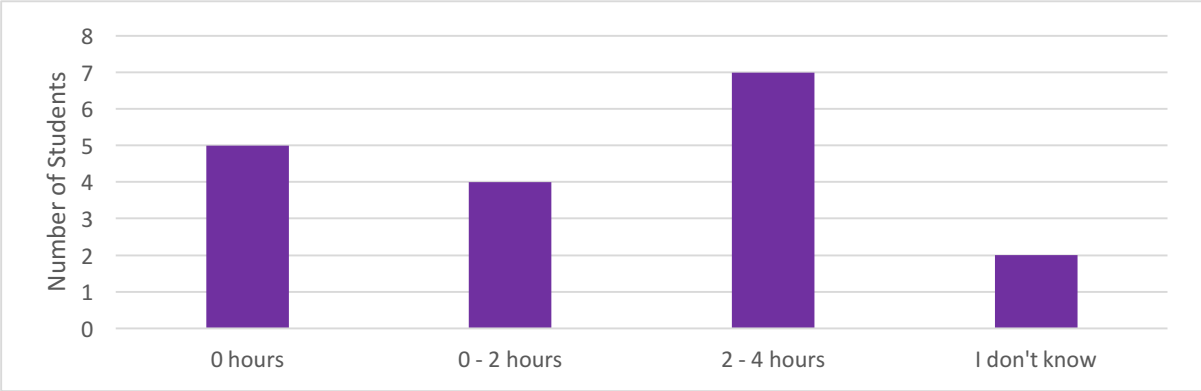

Chart 13 – The number of hours studied by the students who viewed the videos. Most commonly they study between two and four hours a week. This is more than the average for all students displayed in chart 4. However, this can be explained by the fact that 13 out of 18 users are natural science students.

The users' attitudes and psychological aspects regarding math in chart 7 do not differ from the overall values displayed in table 6. This is true even when excluding the considerably more negative social science students, whom are not represented in table 7.

Attitudes towards math		**Psychological aspects regarding math**	
Mean users	3,56	Mean users	3,45
Standard deviation users	0,64	Standard deviation users	0,77
Min users	3	Min users	2
Max users	5	Max users	5

Table 7 – Mean, standard deviation, minimum and maximum value for attitudes towards and psychological aspects regarding math for the students who viewed the videos. These do not differ from the values obtained from all students as displayed in table 4.

Overall it has proven difficult to distinguish the users in terms of their study habits and attitudes towards math. Identifying potential voluntary users could be proven difficult thus adding to the challenges rather than the opportunities in introducing an edtech tool for math. Something that does add to the opportunities associated with edtech for math and the tool is the fact that almost all users, 90%, understood the exercises with the help from the videos. In addition, more than half of them felt more comfortable when they got stuck on an exercise. Since the most common negative aspect towards the videos was that not all exercises were available, these findings point towards the importance of having videos to all exercises available.

5.2 Students Who Did Not View the Videos

By understanding what made the students not use the edtech tool, it is believed that one can increase the understanding of opportunities and, specifically, challenges in introducing an edtech tool for math.

The non-users stated that the most common reason for not viewing the videos is that they are satisfied with the amount of help they receive in general (see chart 11). This statement relates

to the observed waiting times in both classrooms as the students tended to receive help relatively quickly. It also corresponds with what the economics class' teacher said: 'it exists several free ways of receiving help in math; extra classes, online coach, the supplied tool, other videos and so on'.

Another common trait among non-users is that they are satisfied with the number of hours that they study outside class; 68 % of non-users made this statement in the first survey. As can be understood from comparing chart 13 displaying the average amount of time the non-users spend studying outside of class, to chart 4 displaying the average amount of time all students study outside class, there is no difference in the relative number of students not studying. The non-users stated that they are satisfied with the amount of help they receive and that they do not feel the need of another complement to their studies. This argument is further supported by responses from the group interviews where several students said that they did not feel the need to view the videos. However, it is worth noting that one reason for the lack of need is the lack of hours studied, as indicated in the two leftmost bars in chart 14. This argument is supported by statements made during the group interview with economics students. Many of these students only do math in class.

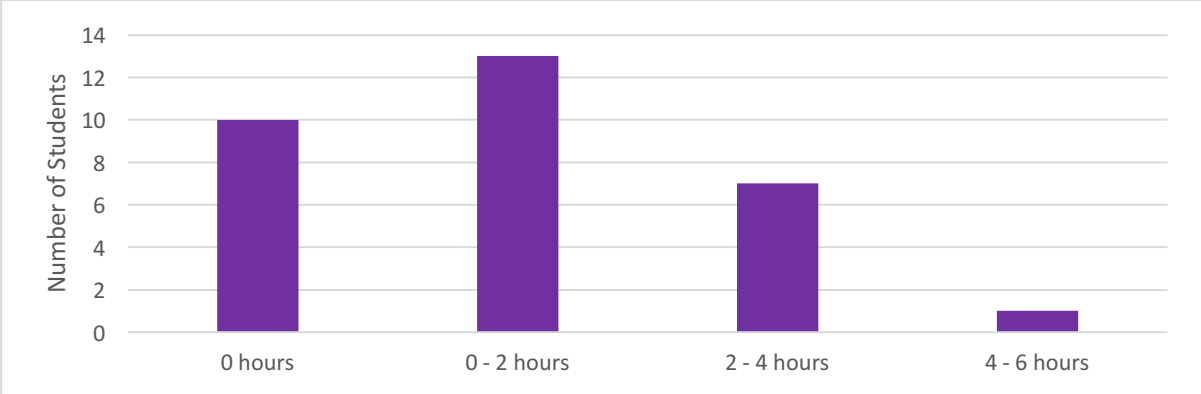

Chart 14 – The number of hours studied by the students who did not view the videos. Most commonly they study less than two hours a week. This is the same as for all students displayed in chart 4.

The attitudes towards and psychological aspects regarding math among the non-users are not worse than the overall values displayed in table 4. This is true even when excluding the considerably more negative social science students, whom are not represented in table 8.

Attitudes towards math		**Psychological aspects regarding math**	
Mean non-users	3,49	Mean non-users	3,54
Standard deviation non-users	0,78	Standard deviation non-users	1,24
Min non-users	1	Min non-users	1
Max non-users	5	Max non-users	5

Table 8 – Mean, standard deviation, minimum and maximum value for attitudes towards and psychological aspects regarding math for the students who did not view the videos. These do not differ from the values obtained from all students as displayed in table 4.

Overall the non-users are not worse than the general population studied in terms of study habits and attitudes towards math. They are representative of this sample and hence subject to the challenges Swedish high school students constitute regarding introduction of edtech for math. The lack of math studied outside of class and the neutral attitudes towards math as a subject appear to prevent adoption of edtech for math.

5.3 Comparison Between Students Who Viewed the Videos and Students Who Did Not

Comparing the users to the non-users helps in understanding how edtech is perceived. As can be understood from comparing table 7 to table 8, the attitudes and psychological aspects do not considerably differ. When comparing the relative amounts of users and non-users that are happy with the number of hours they study outside of class, there is no considerable difference. Furthermore, no noteworthy differences between users and non-users were found in terms of what the students do when they get stuck on an exercise in and outside class. Interestingly there is no substantial difference in how common it is for users/non-users to search for solution videos when they get stuck on an exercise outside class either. Overall no major differences could be identified between users and non-users in terms of study habits, attitudes and psychological aspects regarding math. The comparison between the two groups gives insight into the challenges rather than the opportunities in introducing an edtech tool for math.

5.4 Students Who Do Not Study Outside Class

The empirical findings show that many students do not study outside class (chart 4). These students will henceforth be referred to as *non-studies*. The large number of non-studies could explain why the tool was not used by more students. Out of the 15 non-studies that were given access to the video tool 10 became non-users.

Given their current state of not studying outside of class it is understandable that the majority became non-users. This constitutes a major challenge in introducing edtech for math. However, if their rationalities for not studying could be understood and targeted opportunity exists for the right tool.

Chart 15 shows the reasons why students do not study math outside class. These need thus to be overcome by an edtech tool for math. Only the most common reasons are displayed. All reasons listen below were given by at least six non-studies, 20 %.

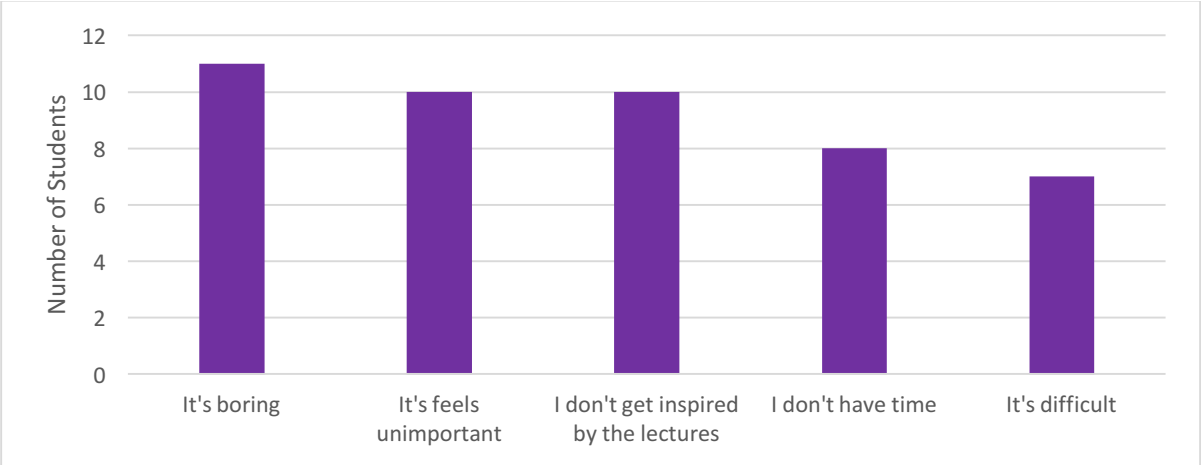

Chart 15 – Main reasons for not studying outside class by the students who do not study at all. Most commonly these students find math to be boring, unimportant and the lectures to be uninspiring.

Table 9, presenting only non-studies, shows that the students are not motivated to maintain or improve their grades when the level of difficulty increases. In chart 11 it is shown that the two most common reasons to not viewing the videos were 'I get the help I need' and 'I reach

my goals in math without using the videos'. This could potentially mean that the students who do not study outside class and state that they reach their goals, may have lowered their goals.

		Aimed grade					
Grade in previous math course		A	B	C	D	E	I don't know
	A	5	3	1	-	-	-
	B	-	3	2	-	-	-
	C	-	1	2	-	1	-
	D	-	-	-	-	3	1
	E	-	-	-	-	2	-
	I don't know	-	-	1	-	-	-

Table 9 – Current and aimed grades for the 25 students who do not study outside class. These students commonly aim for lower grades than they received in their previous math course.

Moreover, one third of the students who do not study outside of class stated that it is because math is difficult. This group of students seemingly represent what was obtained from the second interview with the economics class' teacher as 'the ones who would need the tool the most, but the ones who are the least likely to try it'.

5.5 Motivation Amongst the Students

This section describes the students' motivation. This was identified as a major factor regarding the students' study habits determining the perception and reception of edtech for math. Furthermore, motivation appear to be of great interest to the opportunities and challenges associated with introducing and edtech tool for math. The empirical data revealed a difference in motivational behavior and study habits between the economics and social science students on one hand and the natural science students on the other hand. The findings are thus presented separately to enable identification of a plausible audience for an edtech tool. This will be further explored in the discussion.

The Unmotivated

Only 17 % of the economics students stated that they are satisfied with the number of hours that they study. Main reasons given for not studying are that they have time constraints, it is difficult, they do not get inspired by the lectures and that studying math is boring. They have declining grades, but as the majority stated, they are reaching their (relatively low) goals in math. 50 % of the students stated that they received the help they need and 50 % stated that they reach their goals. The remaining students could have a need for a supportive tool in their studies. 40 % of the students think math is boring, 30 % stated that they feel unmotivated in terms of math and 30 % skip the entire exercise if they get stuck. This non-motivational behavior came forth during the interviews with the teachers, that the students are not willing to put in the effort for succeeding or overcome obstacles. 50 % of the students stated that they would have viewed the videos if they were more motivated in math.

Around 30 % of the economics students find solutions by themselves when they get stuck on an exercise. Less than 40 % would rather view the videos than ask their teacher. During the observations it was shown that the students are unwilling to ask for help, and it is usually initiated by the teacher. The data showed that nearly 80 % of the economics students get stuck during the lectures, meaning that a tool could help the students while studying math. The majority does not strive at improving their grade, there are actually more who aim for a

lower grade, which probably is an effect of the fact that only 10 % of these students have positive attitudes towards math.

Regarding the social science students, it can be noted that none of them are happy with the amount of math they study outside class, 60 % of them said it is because math is difficult and more than 50 % said it is because they do not get inspired enough by the lectures. More than half of them also agreed to not having access to enough help outside of class.

The Motivated

Just over 90 % of the natural science students stated that they receive the help that they need and just over 70 % state that they reach their goals in math. 75 % state that they ask their teacher for help when they get stuck, and 80 % would rather ask their teacher than watch the videos. This is strengthened by the measurements from the observations; 29 out of the 50 students who asked for help during the observations got instant help. Furthermore, the students do not get stuck as often as the economics students; no one stated that they got stuck multiple times per class. These findings point towards a lower demand for a supportive tool in this particular demographic.

Approximately 70 % has a positive attitude towards math, and 65 % has no negative psychological aspects towards math. Half of the students think that math is easy, and the majority wants to receive or maintain a high grade in their current course. The majority are satisfied with the number of hours they study, and they study more than the economics and social science students outside of class. In addition, 40 % of the students have family to ask for help when they study at home. There is only one natural science student who do not study outside class.

During the observations and the interviews, it was found that the students were indecisive when asking for help, perhaps not to look stupid in front of their classmates. Furthermore, this could be the reason for most of them to sit and study by themselves and not asking friends for help. Only 7 % state that they ask a friend for help, which could be as possibility for a tool aimed at the modest students.

There are findings implicating that certain natural science students could be targeted with a supportive tool. However, it has been deemed as a secondary option, compared to the economics students and social science students as is further evaluated in the discussion.

5.6 Other Opportunities and Challenges Related to Attitudes and Psychological Aspects

Regarding how different students perceive math, the findings showed no considerable differences between boys' and girls' attitudes and psychological aspects regarding math. It is therefore difficult to suggest who would benefit the most from edtech for math. Neither any noticeable correlation (above 0.7) was found between any of the three variables: attitudes, psychological aspects and gender (Appendix 5). However, some interesting relationships were found regarding other aspects of attitudes, psychological aspects, math related opinions and study habits. A relationship between disagreeing to receive enough help in class and having negative attitudes towards math was found. The opposite was also found true as thinking one gets enough help in class is associated with having positive attitudes towards math. These relationships are shown in table 10.

I receive the help I need during class			
Disagree and strongly disagree		**Agree and strongly agree**	
Attitudes	Psychological aspects	Attitudes	Psychological aspects
2,32	2,79	3,56	3,64

Table 10 – Comparison between attitudes and psychological aspects for the students who disagree/agree to be receiving the help that they need in class. Students that do not think they receive enough help during class have worse attitudes towards math than do students who think that they receive enough help during class. The students that lack help also experience more negative psychological aspects regarding math.

The collected data show that all students with negative attitudes towards math also experience either negative psychological aspects or do not study outside class, presented in figure 5. The findings show that attitudes towards math can be of importance for the progress of students. This relates to the economics class teacher's belief that approximately 20 % in the economics class get overwhelmed when they are exposed to mathematical problems. The students want to succeed but they do not know where to start, leading to declining interest, and less hours studied. From the group interview it was shown that the students had negative attitudes toward the national tests, since they thought that it would be difficult. However, the students do not study more, but merely accepts the increased level of difficulty. During the observations it was shown that the economics and the social science students were not particularly active during class, with statements such as “this is not even fun anymore,” and was further supported by statements from the teachers during the interviews.

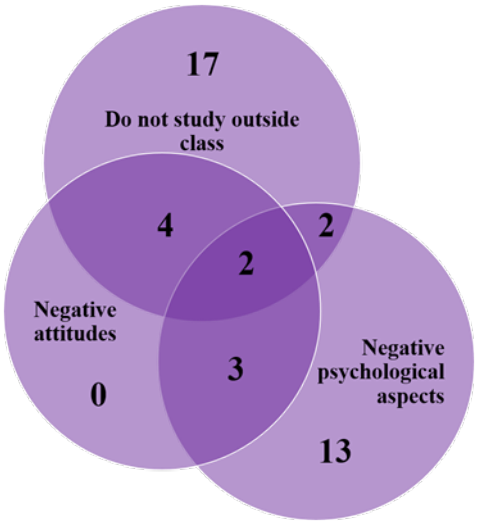

Figure 5 – Relationships between negative attitudes, negative psychological aspects and students who do not study outside class. The figure shows that all students with negative attitudes towards math also experience either negative psychological aspects or do not study outside class. 25 students do not outside class. 9 students have negative attitudes towards math. 20 students experience negative psychological aspects regarding math.

6. Summary of Empirical Findings and Analysis

The empirical findings and the analysis of these together generate answers to the four research questions. The most important insights are displayed in table 11. There are identified interrelations and many insights can thus be associated to more than one research question. These interrelations are explored further in the discussion.

<table>
<tr><th>Q1</th><th>Q2</th></tr>
<tr><td>Opportunities in introducing edtech for math</td><td rowspan="3">Perception and reception of edtech for math
- Many students did not use the tool.
- Users are satisfied with the tool; they understood and felt more confident
- The students used the tool when they got stuck.
- The students would use the tool before an exam.
- The students would use the tool as a last-minute solution.
- The students are open to new technology while studying math.
- The natural science students are likely to try the tool but have other means of receiving help.
- The economics students are unlikely to try the tool, unless right before an exam.</td></tr>
<tr><td>- Motivate the unmotivated; make the students study more and aim higher.
- The students that do not ask the teacher for help or have access to help at home.
- Students with low confidence in math.
- Students recommend tools they like to their classmates.
- Change of attitudes and increase of motivation.</td></tr>
<tr><td>Challenges in introducing edtech for math
- Poor attitudes; many students do not study outside class.
- Difficulties in distinguishing potential users from non-users.
- Competition from other services.
- A new tool must be superior to already established means of receiving help.
- The ones who would need it the most are the least likely to try it.
- Teachers are overwhelmed with offers about new edtech.</td></tr>
</table>

Q3	Q4
Perception of math as a subject - Neutral attitudes overall. - Important, but difficult and boring. - The economic and the social science students have poor attitudes. - The natural science students have better attitudes. - Negative attitudes relate to negative psychological aspects and/or avoidance of math. - Not receiving enough help leads to negative attitudes.	Study habits regarding math - Study habits are affected by attitudes. - Math being boring and difficult cause avoidance of math outside class. - Relationships between negative attitudes and not studying math outside class exist. - Many economics and social science students are not satisfied with the amount that they study. - Natural science students are satisfied with the amount that they study.

Table 11 – Summary of the findings from the empirical data and the data analysis. The study's four research questions are displayed with their related findings. However, due to interrelations between the questions, the insights can be associated to more than one research question.

7. Discussion

Many factors relevant to the study's aim were identified as part of the empirical findings and data analysis parts. The observations in combination with the two surveys and interviews with the teachers and students contribute to an understanding of several aspects relating to the students' perception of math and them either studying or avoiding math inside and outside of class. The study has also revealed some aspects regarding the perception and reception of edtech for math. This has in turn brought some insight into opportunities and challenges in introducing an edtech tool for math.

The chapter starts by presenting some of the most important factors identified regarding the perception of math as a subject, Q3; motivation, attitudes and psychological aspects, and students' study habits, Q4. This is followed by a section describing the classroom context in which the edtech tool was introduced. In exploring how edtech for math is perceived and received, Q2, through the introduction of one tool positive outcomes as well as barriers to implementation were identified. The chapter ends with a discussion about opportunities and challenges in the introduction of edtech for math, Q1, and how future research can contribute to this specific area.

7.1 Perceptions of Math and Study Habits

The following section aims at answering Q3 and Q4 about how math is perceived as a subject and how the students study math.

7.1.1 Motivation Determines Study Habits

One finding that appears to relate to the students' perception of math as a subject and their study habits, Q3 and Q4, is the one of motivation. Motivation was on the agenda from beforehand as the literature review, You et al. (2015) and Lao et al. (2017) for instance, suggested several topics related to motivation such as intrinsic- and extrinsic motivation, expectations and perceived importance and difficulty of math. Motivation was also identified as a major factor regarding how, when and if the students study math. The construct of attitudes towards math closely relates to motivation as it was found that the more positive attitudes the students had, the more they studied in and outside of class. This can be seen by for example comparing the natural science students to the other two classes. Each class was found very consistent in the motivational behavior that its members express and it is therefore often relevant to discuss the findings class-wise, given the aim of this study. To do so enables identification of patterns of interest to all four research questions.

It seems as if the natural science students have a fortunate combination of what You et al. (2015) refer to as intrinsic and extrinsic motivation in math. Their teacher was encouraging them to ask for help and many of them had access to help at home, plausibly associated with supportive parents. This brings Johansson's (2016) concern about inequality to mind. It could be so that these parents are among few today that have time to help their children doing homework. However, there seems to be a fair bit of intrinsic motivation as well as the students perceive math as being important. Not surprisingly these students have positive attitudes towards math and show motivational behavior in and outside of the classroom, as understood from observations and surveys, and the fact that more than half of them were interested enough to view the solution videos. Many students asked for help during class which was predicted by the 75 percent that said that they preferred receiving help from their teacher. It

is also likely that these students are reasonably goal-oriented, firstly to have gotten accepted into the natural science program and then to proceed into university with good grades. This hypothesis is supported by the correlations between goals, learning strategies and achievements explained by Lao et al. (2017).

Lack of motivation was found to be affected by attitudes as well. The number one reason for not studying outside of the classroom among the ones who do not, was found to be that "*it is boring*", followed by "*it seems unimportant*" and *"I don't get inspired enough by the lectures*". "*It's difficult*" was also a top five explanations among these students. Three out of four of these measures: math being boring, unimportant and difficult make up the concept of negative attitudes as formulated in this study. No social science students and almost no economics students stated: "*I'm happy with the amount of time I study*" and only natural science students said that they normally "*finish what they have to in class*". Apart from lack of motivation to study outside class, the observations in combination with the different interviews, revealed a lack of motivation among the economics and social science students. This was manifested as fewer students asked for help than what would be suggested by the frequency with which they normally get stuck on an exercise and their preference to ask their teacher or friends for help. It was also implied by the economics' class teacher who said that when it is "*too much or too difficult some students simply don't know where to start*". The effect of lack of motivation on performance as suggested by You et al. (2015) seem to have started on these students as they gradually accept worse grades as the level of difficulty increases.

However, even the seemingly unmotivated students seem to think that math is important and that passing is necessary to reach career goals. Nevertheless, the perception of math being boring and difficult appears to have taken the overhand. It is possible that these students have failed to internalize their ultimate goals into intrinsic motivation and learning strategies as suggested by Lao et al. (2017).

7.1.2 Students that Experience Negative Psychological Aspects Study Less

The results from this study found a strong correlation (0.84) between all factors chosen to determine negative psychological aspects: anxiety, stress and feeling of being unsuccessful. The presence of such negative emotions regarding math then appears to be associated with negative study behavior. More students that experience negative psychological aspects regarding math were found to be studying less in general and perform worse. This insight is enabled through e.g. comparing the number of hours studied and the grades obtained between the three studied classes, placing the natural science class and the social science class on each side of the spectrum. Among the three factors making up the construct of negative psychological aspects (math) anxiety is deemed to be the most interesting one, thanks to being popular in previous research. The relationship between math anxiety and weak performance is thoroughly explored by researchers such as Dowker (2004), Maloney and Beilock (2012) and Ashcraft and Krause (2007). They present different explanations for the relationship, all of which are possible in this case. Dowker (2004) as well as Ashcraft and Krause (2007) refer to math anxiety commonly causing avoidance of math. Dowker (2004) blames children's math shy behavior on the bad influence from math anxious parents. The fact that the social science students are twice as unlikely to ask their parents for help than are the natural science students could potentially reveal such a predisposition for fear of doing

math as Dowker (2004) refers to. Ashcraft and Krause (2007) explain weak performance in math with avoidance of math caused by math anxiety. These relationships are all apparent in this study's findings.

Despite abovementioned indications of math anxiety, avoidance of math and poor achievements being related, it is not obvious how they are related. It appears likely that fear of math causes avoidance of math and thus weak performance due to lack of practice, but it is also possible that this effect is multiplied as weak performance could cause low confidence and even more anxiety and avoidance of math. This study alone is not enough to determine the correlation and potential causation between the factors studied. However, it appears likely that some sort of downward spiral takes place when negative psychological aspects, math anxiety in particular, are present. Another potential explanation adding to the likelihood of multiplied negative effects of math anxiety is the one about neurological aspects presented by Maloney and Beilock (2012). The math anxious students participating in this study might not only be avoiding math, they might also perform worse than they could have as a direct consequence of their math anxiety. Statements such as math being difficult and feeling unsuccessful are potential signs of counterproductive mental images. The observations in the economics and social science classrooms revealed many signs of students giving up. These feelings of hopelessness might have been planted in the students as early as when they first started school and might also be difficult to get rid of, according to Larkin and Jorgensen's (2015) research.

7.1.3 Students with Negative Attitudes Avoid Math or Experience Negative Psychological Aspects Regarding Math

The fact that some students choose to study less when the level of difficulty increases and accept worse grades as a consequence, point towards a correlation between attitudes and performance, potentially through the presence of negative psychological aspects causing avoidance of math. It could also be that poor attitudes directly cause the students to avoid math. All the students who revealed negative attitudes towards math also experience either negative psychological aspects or do not study at all outside of class, meaning that attitudes are important in terms of students' well-being and study habits. Furthermore, students that have more positive attitudes towards math study more outside the classroom and experience less negative psychological aspects relating to math. There was a suspicion that these students, mainly natural science students, might experience performance related stress and anxiety, but no significant relationship could be found. All these factors stress the importance of working with students' attitudes towards math. Among the three factors used to determine attitudes towards math, math being difficult and boring are the ones mainly responsible for negative attitudes and hence the most important to improve.

The fact that negative attitudes were found to cause avoidance of math and/or negative psychological aspects among all students with negative attitudes, together with the fact that math positive students study more and experience less such negative psychological aspects, imply that attitudes and psychological factors could be correlated. However, no such correlation was found between the constructs of attitudes and psychological aspects as stated in 5.6. The fact that the students generally find math important bettered the attitudes towards math. If attitudes towards math would have been measured as a value based on it only being

fun/boring and easy/difficult the overall attitudes towards math would likely have been lower, potentially revealing a stronger relationship with psychological aspects.

Despite not always leading to negative psychological aspects regarding math it appears important to improve poor attitudes. Firstly, the fact that negative attitudes cause some students to suffer should be reason enough. Secondly, the fact that negative attitudes cause avoidance of math in the remaining cases stresses the importance of working with attitudes.

Regarding having positive attitudes towards math, it was found to differ among demographics. Again, the difference between the classes were big and hence addressed. Only around 10 percent of the economic students and social science students respectively were found to have positive attitudes towards math. The number of natural science students that agreed or strongly agreed to be having positive attitudes was more than 70 percent.

Negative psychological aspects regarding math are particularly common among the social science students, for example illustrated by the fact that almost 70 percent of them admitted to feeling unsuccessful regarding math. Furthermore, the fact that the majority of them are girls comes to mind as previous studies such as Eccles and Jacobs (1986), Yee and Eccles (1988), Beilock et al. (2010) and Haylock (2007) found girls' attitudes and psychological relationship to math being negatively affected from a young age for various sociological reasons. The social science class is not big enough in itself to study gender differences, but this was done for the entire population including the economics and natural science class. However, no gender dependent correlations were found in relation to attitudes or psychological aspects. The chosen demographic can partly explain the fact that this study did not find any such gender differences. The natural science class unavoidably consists of individuals that are reasonably strong in math and these girls are thus not representative for the general population of females. The economics class and the social science class should be less undistorted in terms of math performance.

7.1.4 Factors Affecting Motivation, Psychological Aspects and Attitudes

Many factors affecting motivation, psychological aspects, attitudes, performance and thus the students' perception of math were identified throughout the study. These factors answer the *Why:*s in Q3 and Q4, that is why are the students' perceptions of math the way that they are and why do their study habits look the way that they do? The findings were found to overlap what was reviewed in the literature to a large extent. Firstly, the presence of unpleasant psychological factors among almost 30 percent of the economics students, almost 20 percent of the natural science students and at least 70 percent of the social science students is coherent with the fact that there are many publications exploring how math (Dowker, 2004), more than any other subject, commonly cause intimidation and very unpleasant feelings. Secondly there are patterns found in previous studies exploring the development and pre-disposition of math anxiety as well as motivation regarding math. One such pattern, described by for example Neuville and Croizet (2007) and Dowker (2004) is how parents that dislike math transfers their anxiety onto their children and avoid helping them out of lack of confidence and/or ability. Dowker (2004) specifically mentions how children of math anxious parents are pre-dispositioned to develop fear of math themselves. More than 50 percent of the social science students from this study gave lack of help outside class as a reason why they do not study more outside class. Only 20 percent of them ask a parent or sibling if they get stuck

outside of class. This number is 40 percent for the natural science students. Different interpretations of these findings are possible, but they all appear to confirm rather than to contradict above mentioned literature.

It could be a question about parents' willingness and actual or perceived ability to help. The fact that students apply to the natural science program might very well also have to do with their parents' preferences. It appears to not be a coincidence that the studied natural science students were twice as likely as the social science students to have parents that they can and want to ask for help. Relating to what Turner et al. (2004) describe as 'positive attitudes from parents being good for performance' the natural science students interest and performance in math is likely to be spurred by these helpful parents. This could also be related to You et al. (2015) beliefs that expectations from parents as well as rivalry among students lead to high achievements in math. The interview with the natural science class' teacher revealed that there are some competitive elements to the class.

It is possible to speculate that these high achieving students did, or at least had the possibility to, ask their parents for help even at a younger age. According to LeFevre et al. (2009) early exposure to math enabled by math confident parents significantly improves performance. The discussion can also include Sigmundsson et al. 's (2013) findings about the importance of practice in math. If math anxiety leads to avoidance of math, as indicated by this and many other studies, and the opposite is true, then the difference in perceived and actual performance could be explained by a difference in the number of hours spent doing math. It appears as if the students that experience the most negative psychological aspects in relation to math also study the least and that they are the ones who are the most likely to find math boring. Around 60 percent of the social science students for instance gave boredom as the reason why they do not study more.

General attitudes and willingness to do math also appears to be affected by the frequency with which a student gets stuck while doing math. According to data from the group interview with the economics class and the interview with their teacher, getting stuck is frustrating and stressful especially right before an exam. The economics class' teacher said that certain students know that they are likely to get stuck and struggle to get motivated enough to ask for help on an exercise: 'they know that the next exercise will bring new challenges'. The discouragement they feel appears to make them avoid math inside as well as outside of the classroom. However, the teacher's role as a motivator is complicated. Despite being useful when there is a lack of intrinsic motivation as mentioned by this teacher, relating to You et al. (2015), it is impossible from a time constraint point of view and associated with restricting the students' privacy. In reality a middle way was practiced in the studied cases with the teachers walking around in the classroom encouraging the students to ask for help. The benefits of receiving individual help and encouragement was further described as "having a safety net" by one of the economics students. The fact that many students preferred asking the teacher, friends, parents or siblings to searching for help on their own, adds to this theory about the comfort of having someone to rely on while studying. Furthermore, the students that in the first survey stated that they lacked these kinds of resources as show in table 10, also expressed the most negative attitudes and psychological aspects regarding math.

7.2 Can the Classroom Context be Improved with Edtech?

The exploration of the students' perceptions of math and their study habits help framing the context in which the edtech tool was introduced. The performed study adds to the picture given by the literature review; there are areas of improvements regarding math in Swedish high schools. The teachers appear to be doing their job well, but there are other problems related to the students and their attitudes and anxiety, or even fear of math. Among students that are less specialized and interested in math, but still obliged to take math courses to qualify for university, some disheartening findings have been made. 'Not everyone has to like math' to paraphrase the teacher of the natural science class, but since many students need it to achieve their professional goals and spend many hours compelled to do it throughout school, it is desirable to make it less unpleasant. The teachers shared their experiences of having taught classes from different programs and said that 'some students just want to pass the course'. This is perceived as an important finding in this study. The aim of math lectures and edtech for math should probably not be to make everyone love math. It would perhaps be more beneficial from a societal and commercial point of view to help the students who are struggling with motivation and poor attitudes to reach their own goals. This relates to what the economic class' teacher said about keeping math simple to avoid confusing the most challenged students.

The intended use of the edtech tool introduced in this study is, as previously mentioned, to make students more independent when studying math. This intention is thus inspired by the assumed long waiting times in Swedish Classrooms, implied by e.g. Skolverket (2015). Compared to the other problems, regarding perception of math and study habits, the actual waiting times appears to be a minor problem. However, there are indications that the short waiting times measured relate to students not asking for help despite needing it, hence making the edtech tool potentially more needed than it first appears. Understanding the classroom context should increase the understanding of why edtech for math is perceived and received the way it is, Q2, and the opportunities and challenges that the introduction is associated with, Q1.

7.3 Perception and Reception of Edtech for Math

The following section aims at answering Q2 about how edtech for math is perceived and received by students and teachers. Included in perception and reception are positive outcomes and barriers to implementation.

7.3.1 Positive Outcomes of the Introduction

Among the students that tried the videos the majority said that they did so because they got stuck on an exercise. Out of these users more than half of them felt more comfortable when getting stuck after receiving access to the videos, similar to Straw et al.'s (2015) findings about increased confidence in math. In addition to these facts, almost all users understood with help from the videos. This relates to Choi & Johnson's (2010) conclusion about video-based learning being beneficial in terms of motivation and students' ability to remember what they have learned. In combination with the finding that students that get stuck frequently and/or find math difficult, study less outside of class because of growing negative attitudes towards math it constitutes potentially positive news for the video medium. This further relates to Skolverket's (2017) statement about edtech being particularly beneficial for students that for different reasons has difficulties to reach the goals for their education. The finding of the

students becoming more comfortable when getting stuck on an exercise also relates to Ruthven and Hennessy's (2002), Deaney et al.'s (2003) and Vale and Leder's (2004) similar findings of increased motivation and enjoyment in math after having introduced edtech. Furthermore, it ties in to the fact that not receiving enough help was found to be affecting attitudes towards math negatively. If one can decrease the need for external help by using solution videos instead, the students' attitudes could evidently change into feeling more comfortable. Eventually long-term use of this kind of edtech might make certain students turn this new confidence into motivation to study math in general. As has been suggested by relationships between negative attitudes, avoidance of math and/or negative psychological aspects, identified in this study as well as by Ashcraft & Krause (2007), decent attitudes towards math are essential to expose oneself to math. Since attitudes are negatively affected by thinking one do not receive enough help, and this demonstrably causes avoidance and/or negative connotations regarding math, then edtech for math should aim at reducing the negative attitudes by making the students less dependent on help from the teacher. The edtech tool for math introduced in this study seems rather successful in doing so.

The actual effect on performance was not measured in this study due to its short-term nature, but it would undoubtedly have been desirable. The fact that previous research such as Spradlin et al. (2009) have difficulties establishing actual performance improvements as a result of edtech implementation in math, makes it particularly desirable. There is an obvious justification for interpreting results relating to increased motivation as likely to spur actual performance at some point; publications such as You et al. (2015), Lao et al. (2017) and Sigmundsson et al. (2013) have found that motivation, such as goal orientation and practice, significantly benefit performance in math related tasks. However, there appear to exist more studies concerning perceived rather than actual effects on performance from edtech for math, this study is no exception.

7.3.2 Barriers to Implementation

One major aspect in perception and reception of edtech for math in general and this video-based tool in particular is that of barriers to implementation. Six barriers were identified, two suggested by the theoretical framework and four previously unfamiliar. The first two barriers: lack of math studied outside of class and teachers' negative attitudes towards edtech for math were brought up by Straw et al. (2015) and Pierce and Ball (2009). The remaining four barriers were not suggested by the literature review. Some discussion regarding how to overcome certain barriers is presented.

Lack of Math Studied Outside of Class

An identified problem is that a minority of the students tried the videos. Unfortunately, the reason is not that they had other means of receiving help. There were other means of receiving help measured in the surveys as well as brought up in the group interview, but they do not account for the lack of usage of the tool. The majority of these student do not study at all, or almost not at all outside of class. Many of them do not study in the classroom either. This corresponds with what Straw et al. (2015) describe as lack of "homework policy": an identified barrier to implementation of edtech for math. To succeed with the introduction of edtech tools for math they recommend schools to first assure that they have a satisfactory homework policy. However, the starting point of this study was different. The approach was to study which kind of students would assimilate the edtech tool in an unconditional manner.

Teachers' Negative Attitudes Towards Edtech for Math

On one hand the teachers are crucial for motivation in general and to motivate the students to try new things in particular; this was found in this study as well as Straw et al.'s study (2015). On the other hand, many teachers are overworked as understood from Skolverket (2017) and the mere fact that a small percentage of the teachers asked to participate in this study agreed to do so, the most common reason for not participating being lack of time. This relates to two out of three barriers to implementations mentioned by Pierce and Ball (2009). The (fear of) loss of teaching hours and the lack of will from teachers to change and learn how and when to use a new technology both seem apparent in this case. It is tempting to describe the dilemma as a paradox where the teachers to save time first need to spend time on implementation. However, this appears to be only partly true. It seems important for edtech developers to listen to the math teachers.

One teacher said that they are overwhelmed by companies trying to sell their services as well as statements about the necessity of digitalization from self-acclaimed experts, which is in line with Quillen's (2010) statement about math teachers having access to a vast amount of edtech tools. It might also be unethical and outside the scope of the math teacher's mission to turn them into involuntary promoters of a certain tool. The identified importance of taking teachers' preferences into account for successful implementation also relates to Manches et al.'s (2012) statements about the necessity for edtech developers to work with teachers and students.

The economics class' teacher stated that their reason for joining the project was that anything that would make the students study more would be appreciated. However, the will from teachers to totally reform the school system with technology was not apparent in any of the studied cases. The faith in and predictions about edtech expressed by Swedish school authorities such as Skolverket (2017) and the Swedish Parliament (Riksdagen, 2016) seem to, at least partly, contradict the preferences of the interviewed teachers. These authorities' involvement might be necessary for implementation on a large scale given one of the barriers to adoption identified by Pierce and Ball (2009); not all students may be able to pay for the tool. The inequality aspects of charging students could be solved by governmental founding. Founding of this kind could potentially work as an investment if the use of technology would increase efficiency. Straw et al.'s (2015) study is mentioning this potential cost saving and Kulik and Kulik argued already in 1991 that teachers could save time by partly substitute their lectures with digital introductions. Nonetheless, to achieve this there are elements of the current situation one first must address.

To achieve mainstream adoption of any tool appears to require full commitment by the teachers. The teacher's role in the digitalization era is addressed in a report made by the Swedish Parliament in 2016 proposing a change from planning of education to planning of teaching. This relates to strategies to adoption of edtech videos as part of flipped-classroom practices, as proposed by Straw et al. (2015) who suggest making viewing compulsory as part of the homework. However, this would then probably interfere with the students' freedom to choose their own learning method.

Lack of Early Adopters

Another identified barrier to implementation is the lack of early adopters. The surveys as well as the group interviews revealed that non-user students would have viewed the videos if someone else would have recommended them. The students seem to be careful with their time as they prefer someone else being the “risk taker”.

Students’ Lack of Motivation in Math

The students’ general motivation in math was found to also affect if they decided to view the videos or not. Despite having fewer videos available than the economics students more natural science students choose to view the videos. The reasons they tried the videos are the same, but the natural science students were more willing to take this step than were the economics students.

This makes the reasons for not viewing the videos and reasons economics students would have viewed the videos particularly interesting. It seems to be related to the students reasoning that they receive enough help and reach their goals regardless if they tried the videos or not. They would only consider using the videos before the national exams or any other major test. This goes hand in hand with them generally not studying outside of class. They also said that they would use them if it was more difficult to reach their goals in math meaning that some of them might set lower goals for themselves than they could.

Competition from Other Learning Tools for Math

The big supply of edtech tools available for math was found to affect the implementation of the introduced tool. The students’ access to other means of receiving help, such as YouTube, makes them impatient with any difficulty signing up or getting started. According to the findings it is essential to provide easy access, fast forwarding and solutions to all exercises. The videos are mainly used when the student is stuck on an exercise thus making full coverage of the books highly desirable. The fact that this is not yet the case was the most common negative aspect mentioned among the users. The supply of other similar services satisfying the need for help, whether it is technology or humans, makes it potentially hard to charge for a service like this unless it is a truly superior product.

The students input on this particular edtech tool relate to Sung et al.’s (2017) findings about mobile phones being preferred to computers. Some students said that an app would have been more convenient than accessing the site through the internet browser on their computers, smartphones or tablets. They also requested features such as reminders that could potentially be managed as notifications from an app. In addition to this they desired increased functionality, such as fast-forwarding options, individualized content and possibility to learn more about certain topics. The main concern should be to provide a better interface and course coverage than certain YouTube channels, as this was revealed to be the main competitor.

Other Established Means of Receiving Help

The power of habits seems to also be a barrier to implementation. Students mentioned that they forgot that they had access to the videos and used YouTube or other means out of habit. The students seem to already have established ways of receiving help. In this natural science class more than 90 percent of the non-users said that they receive the help that they need

and 80 percent of these non-users stated that they prefer asking the teacher to view videos. Half of them think that math is easy and they are generally happy with the amount that they study. When studying outside of the classroom, almost half of the natural science students have family they can ask for help. However, 25 percent of them do search for solutions online either written information or videos meaning that they are familiar with the concept but one third preferred other online videos and 40 percent preferred other services.

More than half of the natural science students had the motivation needed to try out the videos and hence the ability to overcome some of the identified barriers to implementation. If they would be provided with videos to all exercises, there is a chance that some of them would become consumers of video-based learning tools. The videos could be a solution to what their teacher described as "fear of looking stupid in front of their classmates" causing some of them to not ask for help. Only seven percent of the natural science students prefer to ask a friend for help, making them potential users of video solutions. Despite having overcome plausibly the biggest barrier of them all, lacking motivation, these students are subject to other barriers to implementation.

7.4 Opportunities and Challenges Regarding Edtech for Math

This section aims at answering the first research question, Q1, about the prospects for edtech for math. This study has helped unfold the conflicting reality that is the edtech industry. Swedish high schools are undoubtedly facing challenges concerning both the individual and the educational system. At the same time many researchers are predicting a bright future for edtech showing positive results from implementation. This study is one of them, finding that students understand with the help of videos and feel more confident while using them, yet there are major barriers to implementations as has been shown above. There appears to be a mismatch between supply and demand, where demand is perhaps more immature technology-wise than is the supply side. Nevertheless, it seems as if current edtech for math is mainly inefficient in curing the main cause of the problem, being lack of motivation. The tools themselves, as the one studied, are generally appreciated while used.

However, the students are not easily impressed as they rather not study at all or have already established ways of receiving help. The dilemma can be illustrated by a quote from the economics class' teacher saying that "*the students that need it the most might be the least likely to try*". One reason for these students to not try could be that they fail in setting goals and hence strategies to reach any goals, as suggested by Lao et al. (2017). Without a strategy of learning there is no room for new aid as learning is simply not taking place.

For a math learning app, service or tool to sell itself it must be extraordinary, but even then, it is likely to need the help of early adopters acting as influencers. If the technology is to make it the official way as part of the course content the teachers need to be fully onboard. If one chooses to target students directly there are more or less suitable candidates. Students with similar characteristics as the economics and social science students in this study, possessing the unfavorable trait of lacking motivation, are probably the ones to approach with a tool like this.

The fact that unmotivated students tend to aim lower when the difficulty increases, commonly say they lack time to study, find math boring and do not get inspired by lectures make them

elusive but possible as potential users of an edtech tool for math. Only half of the economics students, representing less motivated students in this case, think that they receive the help that they need. Furthermore, less than 40 percent of the non-users said that they prefer to ask the teacher to view the videos. One fifth of all economics students and one fifth of all social science students skip the exercise when they get stuck outside of class.

They thereby represent what could be a group of interest. There are also indications that unmotivated students could benefit from a tool like this in the classroom. Many economics students stated that they usually get stuck one or multiple times per class and the most common preference for receiving help in class among them is from the teacher. This leads to predictions about a certain number of students asking for help each class. These predictions turned out to be heavily overestimated for the economics class, and indicate that there are students not asking for help although they need it. The problem appears to stem from a lack of motivation, math anxiety, boredom and related issues. The observation is in line with both teachers saying that some students would have to be motivated individually to ask for the help that they need. The natural science class stood out with many students asking for help, but had some similar traits with many students being shy while asking for help, as understood from observations and the interview with their teacher. This finding could make an edtech tool with solution videos popular as these students can work in their own pace without asking the teacher for help if that makes them uncomfortable. The fact that half of the non-using economics students also said that they would view the videos if they would have been more motivated in math further supports the explanation that lack of motivation causes students to not demand help that they need.

Given the fact that these economics students also commonly said that they would use the videos when and if they did not have anyone else to ask, one can assume that the videos cannot substitute but perhaps supplement a mentor or a teacher. As You et al. (2015) state; external motivation from someone else could make up for lack of internal motivation. Adding motivational elements such as reminders or milestones to the tool could help although it does not necessarily give the same effect as a dedicated teacher or parent. To increase intrinsic motivation seems challenging regardless of resources, but there is a possibility that extrinsic motivators, such as progress made visible, could help the students study more. One argument for persuasion of unmotivated students is that math after all is considered important by most students. It is the fact that it is considered boring and difficult that give rise to the negative attitudes. If these issues could be addressed and partly solved with edtech for math, then there are reasons for being optimistic. The students said that they perceive edtech of this kind to be helpful rather than additional work thus making it a potential way of making studying more efficient.

If these students manage to turn the increased confidence from having access to videos when getting stuck into studying more, and thereby further reduce their math anxiety through exposure to math, real effects on performance are viable. This argument is supported by both Dowker (2004) and Turner et al. (2004) and their studies of math anxiety versus math confidence's effects on people's agreement to do math. It also relates to Sigmundsson et al.'s (2013) statements about practice rather than genetic predisposition being the main determinant for mathematical performance. Even if one is to believe Dowker (2004) and her conviction that hereditary factors matter to some extent, it is unavoidably so that exposing

oneself to math increases the chances to improve the mathematical abilities one was dealt. Similarly, to Li and Ma (2005) the research group dares to let positive indicators of increased confidence spur a hope that edtech will eventually lead to better performances in math. The overall result relates to what was found by the Swedish Parliament (Riksdagen, 2016) and Skolverket (2017). There are reasons for being optimistic about the use of edtech especially regarding measured values such as student motivation and confidence. To get the full potential out of whichever tool is used it seems as if time and other long-going efforts to e.g. continuously motivate the students, are needed. This particularly relates to the finding by the Swedish Parliament (Riksdagen, 2016) regarding the importance of teachers adapting a new role in the digital era, actively introducing new means of learning to the students and thus enabling the full benefits of technology in and outside of the classroom.

Another lesson from this study of this tool is that simplicity and structure are appreciated characteristics when learning math. This was mentioned by the economics class' teacher as well as the students claiming that they feel stressed when solution videos were unstructured or used unfamiliar formulas. As far as this study is concerned edtech should not try to be fun, just clear. The students will plausibly perceive math to be more fun as they get stuck less.

Regarding students that are motivated, study enough and reach their already high goals it appears relatively easy to get them to try something new. However, they tend to have their preferred ways of studying and any new technology would have to first outcompete any other source of help making them potentially more difficult to win over than are their unmotivated counterparts.

7.5 Suggestions for Future Research

There are findings in this study indicating that the level of performance in math required from the Swedish high school students is too low with international measures. There are also findings suggesting that improvements could be made to the structure of the high school math courses. These political questions are outside the scope of this study, but relevant for further research. One interesting perspective would be that of governmental investment in edtech for math. The research group also suggests other researchers to study the reception and use of other edtech tools for math more specifically synchronous and asynchronous and collaborative learning as introduced by BrainCert Academy (2015). Further, the research group encourages teacher-focused research where the functionality of edtech is tested and implemented from the teachers' point of view, or even developed together with teachers as suggested by Manches et al. (2012). Teachers are encouraged to try and implement tools of choice as an integral part of their teaching and thereby overcome some of the barriers to implementation encountered in this study. Two barriers were previously mentioned by the literature, whereas four new barriers were identified. These new barriers are suggested for further research in terms of generalizability. There are also interesting opportunities in evaluating the environmental effect of substituting traditional classroom learning with technology.

8. Conclusion

Many factors affecting the opportunities and challenges in introducing an edtech tool for math were identified through the exploration of the four research questions. More specifically the opportunities are based on motivating the unmotivated students and the challenges are illustrated by the six identified barriers to implementation. Two out of these barriers were suggested by the literature review. Four of them are identified as new and suggested for additional research. The opportunities and challenges relate to the findings regarding students' perception and reception of edtech for math, their perception of math as a subject and their study habits regarding math. Conclusions concerning each of the research questions are displayed separately in figure 6.

Q1
What are the opportunities in introducing an edtech tool for math to Swedish high school students and their teachers?
- Motivate the unmotivated; make the students study more and aim higher. - The students that do not ask the teacher for help or have access to help at home. - Students with low confidence in math. - Students recommend tools they like to their classmates. - Change of attitudes and increase of motivation. - Classes are too large to give individualized motivational support.
What are the challenges in introducing an edtech tool for math to Swedish high school students and their teachers?

Barriers to implementation:
- Many students do not study outside class, due to poor attitudes.
- Teachers are overwhelmed with offers about new edtech.
- Lack of early adopters; It is important that some students try, like the solution and encourage their friends to try.
- Students' lack of motivation in math.
  - Difficulties in distinguishing potential users from non-users.
  - The ones who would need it the most are the least likely to try it.
- Competition from other learnings tools for math.
  - A new tool must be superior to already established means of receiving help.
- Both students and teachers believe enough help is provided in class.

Q2
How is edtech for math perceived and received by different kinds of Swedish high school students and their teachers?
- Many students did not use the tool. - Users are satisfied with the tool; they understood exercises and felt more confident. - The students used the tool when they got stuck on an exercise. - The students would use the tool before an exam. - The students would use the tool as a last-minute solution. - The students are open to new technology while studying math. - The economics students are unlikely to try the tool, unless right before an exam. - The natural science students are likely to try the tool, but have other means of receiving help.

Q3
What are different kinds of students' perception of math as a subject and why?

- The students have neutral attitudes overall.
  - The economics and the social science students have poor attitudes.
  - The natural science students have better attitudes.
- Math is seen as important, but difficult and boring.
- Not receiving enough help leads to negative attitudes.
- Negative attitudes relate to negative psychological aspects and/or avoidance of math.

Q4
What are different kinds of students' study habits regarding math and why?
- Study habits are affected by attitudes. - Math being boring and difficult cause avoidance of math outside class. - The students are not motivated to maintain or improve their grade when the level of difficulty increases. - Many economics and social science students are not satisfied with the amount that they study. - The natural science students are satisfied with the amount that they study. - The students do not utilize present tools and support provided.

Figure 6 – Conclusions concerning all research questions displayed separately

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Appendix 1

Jag går på följande program	Boring	Difficult	Importance	Mean
Ekonomiprogrammet	3	2	2	2
Ekonomiprogrammet	3	2	2	2
Ekonomiprogrammet	2	3	2	2
Ekonomiprogrammet	2	3	3	3
Ekonomiprogrammet	2	3	3	3
Ekonomiprogrammet	3	3	3	3
Ekonomiprogrammet	3	3	3	3
Ekonomiprogrammet	1	3	3	2
Ekonomiprogrammet	3	1	3	2
Ekonomiprogrammet	2	2	3	2
Ekonomiprogrammet	3	2	3	3
Ekonomiprogrammet	3	2	3	3
Ekonomiprogrammet	3	2	3	3
Ekonomiprogrammet	4	3	3	3
Ekonomiprogrammet	4	3	3	3
Ekonomiprogrammet	3	3	3	3
Ekonomiprogrammet	3	3	4	3
Ekonomiprogrammet	3	3	4	3
Ekonomiprogrammet	3	3	4	3
Ekonomiprogrammet	1	2	4	2
Ekonomiprogrammet	4	4	4	4
Ekonomiprogrammet	4	4	4	4
Ekonomiprogrammet	4	2	4	3
Ekonomiprogrammet	4	2	4	3
Ekonomiprogrammet	4	5	4	4
Ekonomiprogrammet	3	1	4	2
Naturvetenskapliga programmet	4	3	4	4
Naturvetenskapliga programmet	4	4	4	4
Naturvetenskapliga programmet	4	4	4	4
Naturvetenskapliga programmet	4	2	4	3
Naturvetenskapliga programmet	4	2	4	3
Naturvetenskapliga programmet	4	2	4	3
Naturvetenskapliga programmet	4	3	4	4
Naturvetenskapliga programmet	4	3	4	4
Naturvetenskapliga programmet	4	3	4	4
Naturvetenskapliga programmet	4	3	4	4
Naturvetenskapliga programmet	5	3	4	4
Naturvetenskapliga programmet	5	3	4	4
Naturvetenskapliga programmet	2	5	4	3
Naturvetenskapliga programmet	5	4	4	4
Naturvetenskapliga programmet	4	2	4	3
Naturvetenskapliga programmet	3	2	4	3
Naturvetenskapliga programmet	3	2	4	3
Naturvetenskapliga programmet	4	3	4	4
Naturvetenskapliga programmet	4	3	4	4
Naturvetenskapliga programmet	4	3	1	2
Naturvetenskapliga programmet	4	3	5	4
Naturvetenskapliga programmet	3	3	5	4
Naturvetenskapliga programmet	5	3	5	4
Naturvetenskapliga programmet	5	3	5	4
Naturvetenskapliga programmet	5	3	5	4
Naturvetenskapliga programmet	5	3	5	4
Naturvetenskapliga programmet	5	3	5	4
Naturvetenskapliga programmet	5	5	5	5
Samhällsprogrammet	2	1	5	2
Samhällsprogrammet	1	1	5	2
Samhällsprogrammet	1	1	5	2
Samhällsprogrammet	2	2	5	3
Samhällsprogrammet	3	2	5	3
Samhällsprogrammet	3	2	5	3
Samhällsprogrammet	1	1	5	2
Samhällsprogrammet	2	2	5	3
Samhällsprogrammet	3	2	5	3
Samhällsprogrammet	3	2	5	3
Samhällsprogrammet	3	2	5	3
Samhällsprogrammet	4	3	5	4
Samhällsprogrammet	4	3	5	4
Samhällsprogrammet	3	2	5	3
	3,34783	2,637681	3,9855072	

Jag tycker att matte är	
Väldigt roligt	5
Roligt	4
Varken roligt eller tråkigt	3
Tråkigt	2
Väldigt tråkigt	1
Jag tycker att matte är	
Väldigt lätt	5
Lätt	4
Varken lätt eller svårt	3
Svårt	2
Väldigt svårt	1
Jag tycker matte är	
Väldigt viktigt	5
Viktigt	4
Varken viktigt eller oviktigt	3
Oviktigt	2
Väldigt oviktigt	1

Anova: Two-Factor Without Replication

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Row 1	3	5	1,67	0,33
Row 2	3	4	1,33	0,33
Row 3	3	4	1,33	0,33
Row 4	3	7	2,33	0,33
Row 5	3	8	2,67	0,33
Row 6	3	8	2,67	0,33
Row 7	3	8	2,67	0,33
Row 8	3	8	2,67	0,33
Row 9	3	10	3,33	0,33
Row 10	3	8	2,67	0,33
Row 11	3	8	2,67	0,33
Row 12	3	8	2,67	0,33
Row 13	3	9	3	0
Row 14	3	9	3	0
Row 15	3	7	2,33	1,33
Row 16	3	7	2,33	1,33
Row 17	3	5	1,67	1,33
Row 18	3	12	4	0
Row 19	3	12	4	0
Row 20	3	10	3,33	1,33
Row 21	3	10	3,33	1,33
Row 22	3	10	3,33	1,33
Row 23	3	8	2,67	1,33
Row 24	3	8	2,67	1,33
Row 25	3	9	3	1
Row 26	3	9	3	1
Row 27	3	9	3	1
Row 28	3	9	3	1
Row 29	3	9	3	1
Row 30	3	9	3	1
Row 31	3	9	3	1
Row 32	3	11	3,67	0,33
Row 33	3	11	3,67	0,33
Row 34	3	11	3,67	0,33
Row 35	3	11	3,67	0,33
Row 36	3	11	3,67	0,33
Row 37	3	11	3,67	0,33
Row 38	3	11	3,67	0,33
Row 39	3	11	3,67	0,33
Row 40	3	10	3,33	0,33
Row 41	3	10	3,33	0,33
Row 42	3	10	3,33	0,33
Row 43	3	10	3,33	0,33
Row 44	3	12	4	1
Row 45	3	12	4	1
Row 46	3	11	3,67	2,33
Row 47	3	4	1,33	0,33
Row 48	3	13	4,33	0,33
Row 49	3	13	4,33	0,33
Row 50	3	14	4,67	0,33
Row 51	3	11	3,67	2,33
Row 52	3	11	3,67	2,33
Row 53	3	11	3,67	2,33
Row 54	3	10	3,33	2,33
Row 55	3	10	3,33	2,33
Row 56	3	10	3,33	2,33
Row 57	3	12	4	1
Row 58	3	12	4	1
Row 59	3	12	4	1
Row 60	3	12	4	1
Row 61	3	11	3,67	1,33
Row 62	3	13	4,33	1,33
Row 63	3	13	4,33	1,33
Row 64	3	13	4,33	1,33
Row 65	3	13	4,33	1,33
Row 66	3	13	4,33	1,33
Row 67	3	14	4,67	0,33
Row 68	3	15	5	0
Row 69	3	9	3	4
Column 1	69	231	3,35	1,17
Column 2	69	182	2,64	0,82
Column 3	69	275	3,99	0,84

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	131,98	68	**1,94**	4,36	1,54E-13	1,40
Columns	62,73	2	31,37	70,40	1,03E-21	3,06
Error	60,60	136	**0,45**			
Total	255,31	206				

Cronbach's Alpha	**0,77**

Appendix 2

Jag går på följande program	Stress	Anxiety	Unsuccessful	Mean
Naturvetenskapliga programmet	2	2	2	2
Ekonomiprogrammet	1	2	2	2
Ekonomiprogrammet	4	2	2	3
Ekonomiprogrammet	3	4	2	3
Naturvetenskapliga programmet	3	4	2	3
Naturvetenskapliga programmet	2	3	2	2
Ekonomiprogrammet	1	3	2	2
Naturvetenskapliga programmet	1	3	2	2
Ekonomiprogrammet	1	2	1	1
Ekonomiprogrammet	3	2	1	2
Ekonomiprogrammet	2	3	1	2
Naturvetenskapliga programmet	1	2	4	2
Ekonomiprogrammet	4	4	4	4
Ekonomiprogrammet	4	4	4	4
Ekonomiprogrammet	4	4	4	4
Naturvetenskapliga programmet	4	4	4	4
Naturvetenskapliga programmet	5	4	4	4
Ekonomiprogrammet	3	4	4	4
Naturvetenskapliga programmet	3	4	4	4
Naturvetenskapliga programmet	4	5	4	4
Naturvetenskapliga programmet	4	5	4	4
Naturvetenskapliga programmet	3	5	4	4
Naturvetenskapliga programmet	2	3	4	3
Naturvetenskapliga programmet	2	3	4	3
Naturvetenskapliga programmet	3	3	4	3
Ekonomiprogrammet	1	2	5	2
Ekonomiprogrammet	4	4	5	4
Naturvetenskapliga programmet	4	4	5	4
Naturvetenskapliga programmet	4	4	5	4
Naturvetenskapliga programmet	3	4	5	4
Ekonomiprogrammet	4	5	5	5
Naturvetenskapliga programmet	4	5	5	5
Ekonomiprogrammet	5	5	5	5
Ekonomiprogrammet	5	5	5	5
Ekonomiprogrammet	5	5	5	5
Ekonomiprogrammet	5	5	5	5
Ekonomiprogrammet	5	5	5	5
Naturvetenskapliga programmet	5	5	5	5
Naturvetenskapliga programmet	5	5	5	5
Naturvetenskapliga programmet	5	5	5	5
Naturvetenskapliga programmet	5	5	5	5
Ekonomiprogrammet	3	5	5	4
Naturvetenskapliga programmet	3	5	5	4
Naturvetenskapliga programmet	3	5	5	4
Naturvetenskapliga programmet	2	3	5	3
Naturvetenskapliga programmet	3	3	5	4
Ekonomiprogrammet	2	2	3	2
Naturvetenskapliga programmet	2	2	3	2
Ekonomiprogrammet	4	2	3	3
Ekonomiprogrammet	3	5	3	4
Ekonomiprogrammet	2	3	3	3
Ekonomiprogrammet	3	3	3	3
Naturvetenskapliga programmet	3	3	3	3
	3,226415	3,735849	3,79245283	

Matte gör att jag ofta känner mig stressad	
Instämmer helt	1
Instämmer	2
Varken instämmer eller inte	3
Instämmer inte	4
Instämmer inte alls	5
Matte gör att jag ofta känner ångest	
Instämmer helt	1
Instämmer	2
Varken instämmer eller inte	3
Instämmer inte	4
Instämmer inte alls	5
Matte gör att jag ofta känner mig misslyckad	
Instämmer helt	1
Instämmer	2
Varken instämmer eller inte	3
Instämmer inte	4
Instämmer inte alls	5

Anova: Two-Factor Without Replication

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Row 1	3	6	2,00	0,00
Row 2	3	5	1,67	0,33
Row 3	3	8	2,67	1,33
Row 4	3	9	3,00	1,00
Row 5	3	9	3,00	1,00
Row 6	3	7	2,33	0,33
Row 7	3	6	2,00	1,00
Row 8	3	6	2,00	1,00
Row 9	3	4	1,33	0,33
Row 10	3	6	2,00	1,00
Row 11	3	6	2,00	1,00
Row 12	3	7	2,33	2,33
Row 13	3	12	4,00	0,00
Row 14	3	12	4,00	0,00
Row 15	3	12	4,00	0,00
Row 16	3	12	4,00	0,00
Row 17	3	13	4,33	0,33
Row 18	3	11	3,67	0,33
Row 19	3	11	3,67	0,33
Row 20	3	13	4,33	0,33
Row 21	3	13	4,33	0,33
Row 22	3	12	4,00	1,00
Row 23	3	9	3,00	1,00
Row 24	3	9	3,00	1,00
Row 25	3	10	3,33	0,33
Row 26	3	8	2,67	4,33
Row 27	3	13	4,33	0,33
Row 28	3	13	4,33	0,33
Row 29	3	13	4,33	0,33
Row 30	3	12	4,00	1,00
Row 31	3	14	4,67	0,33
Row 32	3	14	4,67	0,33
Row 33	3	15	5,00	0,00
Row 34	3	15	5,00	0,00
Row 35	3	15	5,00	0,00
Row 36	3	15	5,00	0,00
Row 37	3	15	5,00	0,00
Row 38	3	15	5,00	0,00
Row 39	3	15	5,00	0,00
Row 40	3	15	5,00	0,00
Row 41	3	15	5,00	0,00
Row 42	3	13	4,33	1,33
Row 43	3	13	4,33	1,33
Row 44	3	13	4,33	1,33
Row 45	3	10	3,33	2,33
Row 46	3	11	3,67	1,33
Row 47	3	7	2,33	0,33
Row 48	3	7	2,33	0,33
Row 49	3	9	3,00	1,00
Row 50	3	11	3,67	1,33
Row 51	3	8	2,67	0,33
Row 52	3	9	3,00	0,00
Row 53	3	9	3,00	0,00
Column 1	53	171	3,23	1,60
Column 2	53	198	3,74	1,28
Column 3	53	201	3,79	1,63

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	177,27	52	**3,41**	6,22	0,00	1,47
Columns	10,30	2	5,15	9,39	0,00	3,08
Error	57,03	104	**0,55**			
Total	244,60	158				

Cronbach's Alpha	**0,84**

Appendix 3

Anonym kod	Jag går på följande program	Jag tycker att matte är	Jag tycker att matte är	Jag tycker matte är	Mean	
A56	Economics		3	3	3	3,00
B55	Economics		3	2	3	2,62
C54	Economics		4	4	5	4,31
D53	Economics		1	3	3	2,08
E52	Economics		3	3	4	3,30
F51	Economics		4	4	5	4,31
G50	Economics		1	2	1	1,26
H49	Economics		4	3	4	3,63
I48	Economics		3	2	4	2,88
J47	Economics		4	3	4	3,63
K46	Economics		3	2	4	2,88
L45	Economics		3	2	4	2,88
M44	Economics		3	1	5	2,47
N43	Economics		3	3	4	3,30
O42	Economics		3	3	3	3,00
P41	Economics		3	2	3	2,62
Q10	Economics		3	3	4	3,30
Q40	Economics		4	2	5	3,42
R39	Economics		3	3	4	3,30
S38	Economics		4	0	4	Error
T37	Economics		3	2	4	2,88
U36	Economics		2	3	3	2,62
W34	Economics		2	3	3	2,62
V35	Economics		4	2	5	3,42
x03	Economics		3	1	3	2,08
X33	Economics		4	5	5	4,64
Y02	Economics		2	2	4	2,52
Y32	Economics		2	3	3	2,62
Z31	Economics		0	1	4	Error
33B	Nature Science		4	3	4	3,63
34A	Nature Science		4	2	5	3,42
35Z	Nature Science		5	5	5	5,00
36Y	Nature Science		5	3	5	4,22
37X	Nature Science		4	4	4	4,00
38W	Nature Science		5	3	4	3,91
39V	Nature Science		5	3	4	3,91
40U	Nature Science		5	3	5	4,22
41T	Nature Science		5	3	5	4,22
42S	Nature Science		4	3	4	3,63
43R	Nature Science		4	3	5	3,91
44Q	Nature Science		4	3	3	3,30
45P	Nature Science		4	3	5	3,91
46O	Nature Science		5	3	5	4,22
47n	Nature Science		3	2	5	3,11
48M	Nature Science		2	5	4	3,42
49L	Nature Science		4	3	4	3,63
50K	Nature Science		3	2	5	3,11
51J	Nature Science		5	4	5	4,64
52I	Nature Science		4	2	4	3,17
53H	Nature Science		4	3	5	3,91
54G	Nature Science		4	4	4	4,00
55F	Nature Science		4	2	4	3,17
56E	Nature Science		5	3	5	4,22
57D	Nature Science		4	3	5	3,91
58C	Nature Science		3	3	5	3,56
59B	Nature Science		4	3	4	3,63
60A	Nature Science		4	2	4	3,17
I18	Social Science		3	3	0	Error
J17	Social Science		4	3	4	3,63
K16	Social Science		3	2	4	2,88
L15	Social Science		2	2	4	2,52
M14	Social Science		1	1	2	1,26
N13	Social Science		3	2	3	2,62
O12	Social Science		3	2	3	2,62
P11	Social Science		4	3	4	3,63
R09	Social Science		3	2	4	2,88
S08	Social Science		2	2	3	2,29
T07	Social Science		2	1	2	1,59
U06	Social Science		3	2	5	3,11
w04	Social Science		1	1	3	1,44
V05	Social Science		1	1	2	1,26
Z01	Social Science		3	2	4	2,88

	I think math is boring (1 - 5)	Jag tycker att matte är	Jag tycker matte är	Mean
Mean (Average)	3,31	2,58	3,93	3,22
Standard deviation	1,13	0,96	1,01	0,82

Attitudes towards math	
Mean economics class	3,02
Mean natural science class	3,79
Mean social science class	2,47
Mean all classes	**3,22**
Standard deviation all classes	**0,82**
Min all classes	**1**
Max all classes	**5**

Appendix 4

Anonym kod	Jag går på följande program	Matte gör att jag ofta känner mig stressad	Matte gör att jag ofta känner ångest	Matte gör att jag ofta känner mig misslyckad	Mean
A56	Economics	2	3	1	1,82
B55	Economics	5	5	5	5,00
C54	Economics	4	5	5	4,64
D53	Economics	5	5	5	5,00
E52	Economics	4	4	4	4,00
F51	Economics	4	2	3	2,88
G50	Economics	1	2	2	1,59
H49	Economics	3	5	3	3,56
I48	Economics	5	5	5	5,00
J47	Economics	4	4	4	4,00
K46	Economics	2	3	3	2,62
L45	Economics	1	3	2	1,82
M44	Economics	1	2	1	1,26
N43	Economics	2	2	3	2,29
O42	Economics	4	4	5	4,31
P41	Economics	4	4	4	4,00
Q10	Economics	4	4	4	4,00
Q40	Economics	3	2	1	1,82
R39	Economics	3	4	2	2,88
S38	Economics	2	2	0	Error
T37	Economics	3	4	4	3,63
U36	Economics	5	5	5	5,00
W34	Economics	4	2	2	2,52
V35	Economics	1	2	5	2,15
x03	Economics	2	2	2	2,00
X33	Economics	5	5	5	5,00
Y02	Economics	2	2	2	2,00
Y32	Economics	3	3	3	3,00
Z31	Economics	3	5	5	4,22
33B	Nature Science	4	5	5	4,64
34A	Nature Science	2	3	4	2,88
35Z	Nature Science	3	3	5	3,56
36Y	Nature Science	3	5	5	4,22
37X	Nature Science	3	5	5	4,22
38W	Nature Science	4	5	4	4,31
39V	Nature Science	5	5	5	5,00
40U	Nature Science	5	5	5	5,00
41T	Nature Science	4	4	5	4,31
42S	Nature Science	3	4	4	3,63
43R	Nature Science	4	5	4	4,31
44Q	Nature Science	3	5	4	3,91
45P	Nature Science	2	2	2	2,00
46O	Nature Science	3	4	5	3,91
47n	Nature Science	1	3	2	1,82
48M	Nature Science	5	5	5	5,00
49L	Nature Science	4	4	4	4,00
50K	Nature Science	2	3	4	2,88
51J	Nature Science	5	4	4	4,31
52I	Nature Science	2	3	5	3,11
53H	Nature Science	2	3	2	2,29
54G	Nature Science	4	4	5	4,31
55F	Nature Science	3	3	3	3,00
56E	Nature Science	3	3	4	3,30
57D	Nature Science	3	4	2	2,88
58C	Nature Science	2	2	3	2,29
59B	Nature Science	5	5	5	5,00
60A	Nature Science	1	2	4	2,00

	Matte gör att jag ofta känner mig stressad	Matte gör att jag ofta känner ångest	Matte gör att jag ofta känner mig misslyckad	Mean
Mean (Average)	3,18	3,65	3,67	3,47
Standard deviation	1,26	1,16	1,37	1,12

Psychological aspects in regard to math	
Mean economics class	3,29
Mean natural science class	3,65
Mean social science class	N/A
Mean all classes	**3,47**
Standard deviation all classes	**1,12**
Min all classes	**1**
Max all classes	**5**

Appendix 5

Anonym kod	Kön	Jag går på följande program	Mean Att	Mean Psy
Q40	Kille	Economics	3,42	1,82
V35	Kille	Economics	3,42	2,15
58C	Kille	Nature Science	3,56	2,29
W34	Kille	Economics	2,62	2,52
50K	Kille	Nature Science	3,11	2,88
R39	Kille	Economics	3,30	2,88
34A	Kille	Nature Science	3,42	2,88
Y32	Kille	Economics	2,62	3
52I	Kille	Nature Science	3,17	3,11
H49	Kille	Economics	3,63	3,56
T37	Kille	Economics	2,88	3,63
46O	Kille	Nature Science	4,22	3,91
P41	Kille	Economics	2,62	4
J47	Kille	Economics	3,63	4
O42	Kille	Economics	3,00	4,31
54G	Kille	Nature Science	4,00	4,31
51J	Kille	Nature Science	4,64	4,31
33B	Kille	Nature Science	3,63	4,64
U36	Kille	Economics	2,62	5
I48	Kille	Economics	2,88	5
59B	Kille	Nature Science	3,63	5
39V	Kille	Nature Science	3,91	5
X33	Kille	Economics	4,64	5
M44	Tjej	Economics	2,47	1,26
G50	Tjej	Economics	1,26	1,59
L45	Tjej	Economics	2,88	1,82
A56	Tjej	Economics	3,00	1,82
47n	Tjej	Nature Science	3,11	1,82
60A	Tjej	Nature Science	3,17	2
45P	Tjej	Nature Science	3,91	2
N43	Tjej	Economics	3,30	2,29
53H	Tjej	Nature Science	3,91	2,29
K46	Tjej	Economics	2,88	2,62
57D	Tjej	Nature Science	3,91	2,88
F51	Tjej	Economics	4,31	2,88
55F	Tjej	Nature Science	3,17	3
56E	Tjej	Nature Science	4,22	3,30
35Z	Tjej	Nature Science	5,00	3,56
42S	Tjej	Nature Science	3,63	3,63
44Q	Tjej	Nature Science	3,30	3,91
E52	Tjej	Economics	3,30	4
49L	Tjej	Nature Science	3,63	4
37X	Tjej	Nature Science	4,00	4,22
36Y	Tjej	Nature Science	4,22	4,22
43R	Tjej	Nature Science	3,91	4,31
38W	Tjej	Nature Science	3,91	4,31
41T	Tjej	Nature Science	4,22	4,31
C54	Tjej	Economics	4,31	4,64
D53	Tjej	Economics	2,08	5
B55	Tjej	Economics	2,62	5
48M	Tjej	Nature Science	3,42	5
40U	Tjej	Nature Science	4,22	5

Correlation between			
The students negative attitudes	**The students negative psychological aspects**	**Girls negative attitudes**	**Girls negative psychological aspects**
0,24	0,51	-0,07	0,15

Mean - Attitudes towards math		**Mean - Psychological aspects regarding math**	
Boys	**Girls**	**Boys**	**Girls**
3,4	3,4	3,6	3,1

Appendix 6

Total number of respondents: 72

		Number of respondents	Percentage
Q1	**Gender**		
	Boy	28	39%
	Girl	43	60%
	Prefer not to answer	1	1%
Q2	**I study at the following programme**		
	Economics	29	40%
	Nature Science	28	39%
	Social Science	15	21%
Q3	**During class I get stuck with an exercise**		
	Hardly ever	2	3%
	Multiple times per class	10	14%
	Some time per class	44	61%
	Some time per week	16	22%
Q4	**When I get stuck with an exercise during class I usually**		
	Ask my teacher	41	57%
	Ask a friend	15	21%
	Skip the exercise	7	10%
	Search for videos with solutions online	4	6%
	I don't know	2	3%
	Search for written information online	2	3%
	Check the answer and try to match it	1	1%
Q5	**I get the help I need during class**		
	Strongly disagree	3	4%
	Disagree	7	10%
	Neither agree nor disagree	17	24%
	Agree	23	32%
	Strongly agree	18	25%
	I don't know	4	6%
Q6	**During a normal week I study this much math (outside of class)**		
	0 hours	25	35%
	0 - 2 hours	29	40%
	2 - 4 hours	15	21%
	4 - 6 hours	1	1%
	I don't know	2	3%
Q7	**The reasons why I don't study more outside class is**		
	I don't have enough time	32	20%
	I'm happy with the amount of time I spend studying	21	13%
	It's boring	19	12%
	It's difficult	19	12%
	I don't get inspired by the math lectures	18	11%
	I usually get stuck	13	8%
	I don't get enough help outside the classroom	11	7%
	It seems unimportant	10	6%
	I don't know	6	4%
	I usually finish what I have to during class	4	3%
	I only study before tests	1	1%
	I'm unmotivated in school	1	1%
	Math is easy	1	1%
	Since I don't learn enough in school, it's not worth the effort	1	1%
Q8	**If I get stuck with an exercise outside of class I usually**		
	Ask parents/siblings	26	36%
	Search for videos with solutions online	12	17%
	Search for written information online	9	13%
	Ask my teacher the next class	8	11%
	Ask a friend	7	10%
	Skip the exercise	5	7%
	I never study outside of class	3	4%

	I don't know	2	3%	

Q9	**I think math is**			
	I don't know (N/A)	1	1%	Mean
	Very boring (1)	5	7%	3,35
	Boring (2)	8	11%	
	Neither fun nor boring (3)	24	33%	
	Fun (4)	25	35%	
	Very fun (5)	9	13%	

Q10	**I think math is**			
	I don't know (N/A)	1	1%	Mean
	Very difficult (1)	7	10%	2,64
	Difficult (2)	24	33%	
	Neither easy nor difficult (3)	32	44%	
	Easy (4)	5	7%	
	Very easy (5)	3	4%	

Q11	**I think math is**			
	I don't know (N/A)	1	1%	Mean
	Very unimportant (1)	1	1%	3,99
	Unimportant (2)	3	4%	
	Neither important nor unimportant (3)	14	19%	
	Important (4)	31	43%	
	Very important (5)	22	31%	

Q12	**Math often makes me feel stressed (only economics and natural science students)**			
	Strongly disagree (5)	10	19%	Mean
	Disagree (4)	13	24%	3,23
	Neither agree nor disagree (3)	15	28%	
	Agree (2)	10	19%	
	Strongly agree (1)	6	11%	

Q13	**Math often causes me anxiety (only economics and natural science students)**			
	Strongly disagree (5)	18	33%	Mean
	Disagree (4)	13	24%	3,74
	Neither agree nor disagree(3)	12	22%	
	Agree (2)	11	20%	

Q14	**Math often make me feel unsuccessful (only economics and natural science students)**			
	I don't know (N/A)	1	2%	Mean
	Strongly disagree (5)	21	39%	3,79
	Disagree (4)	14	26%	
	Neither agree nor disagree (3)	7	13%	
	Agree (2)	8	15%	
	Strongly agree (1)	3	6%	

Q15	**When it comes to math I often feel (only social science students)**		
	Unsuccessful	10	67%
	Anxiety	8	53%
	Stressed	8	53%
	None of the alternatives	3	20%

Q16	**In my latest course I received this grade**		
	A	20	28%
	B	23	32%
	C	15	21%
	D	7	10%
	E	6	8%
	I don't know	1	1%

Q17	**In this course I am aiming for this grade**		
	A	28	39%
	B	15	21%
	C	17	24%
	D	1	1%
	E	10	14%
	I don't know	1	1%

Appendix 7

Total number of respondents	49
Students who watched the videos	18

		Number of respondents	Percentage
Q1	**The reasons I viewed the videos**		
	I got stuck on an exercise	13	27%
	I wanted to help the two students from Chalmers	10	20%
	I like to try new things/I was curious	9	18%
	I feel responsibility to try new things when I have the opportunity	5	10%
	I think math is difficult	5	10%
	I think math is important	4	8%
	I'm focused on reaching my goals in math	2	4%
	I think math is easy	1	2%
	The teacher recommended me to try	1	2%
	A friend recommended me to try	1	2%
	I think math is boring	1	2%
Q2	**Where did you view the videos?**		
	At home	12	24%
	In school	5	10%
	At home and in school	1	2%
Q3	**Was there anything positive about the videos?**		
	I understood with help from the videos	16	33%
	It was useful when there was noone to ask for help	15	31%
	It was convenient to not have to wait for help from the teacher	9	18%
	It felt good to not have to ask the teacher	8	16%
	It felt good to not have to ask classmates	7	14%
Q4	**Was there anything negative about the videos?**		
	There were not videos available for all exercises	14	29%
	It was noisy to view the videos in the classroom	3	6%
	It was tedious to create an account	2	4%
	I did not understand with help from the videos	1	2%
	The videos were too long	1	2%
	After using the videos		
Q5	**I try more difficult exercises**		
	I don't know	2	4%
	Strongly disagree	2	4%
	Disagree	3	6%
	Neither agree nor disagree	5	10%
	Agree	4	8%
	Strongly agree	2	4%
Q6	**I study more math**		
	Strongly disagree	3	6%
	Disagree	5	10%
	Neither agree nor disagree	9	18%
	Agree	1	2%
Q7	**I don't get stuck as frequent as before**		

	I don't know	1	2%
	Disagree	7	14%
	Neither agree nor disagree	5	10%
	Agree	4	8%
	Strongly agree	1	2%

Q8	**I spend less time waiting for the teacher when I need help**		
	I don't know	5	10%
	Strongly disagree	4	8%
	Disagree	2	4%
	Neither agree nor disagree	4	8%
	Agree	2	4%
	Strongly agree	1	2%

Q9	**I feel more motivated in math**		
	I don't know	1	2%
	Disagree	7	14%
	Neither agree nor disagree	9	18%
	Strongly agree	1	2%

Q10	**I feel more secure when I get stuck**		
	I don't know	1	2%
	Disagree	2	4%
	Neither agree nor disagree	6	12%
	Agree	7	14%
	Strongly agree	2	4%

Q11	**I feel less anxious**		
	I don't know	3	6%
	Strongly disagree	4	8%
	Disagree	3	6%
	Neither agree nor disagree	4	8%
	Agree	3	6%
	Strongly agree	1	2%

Q12	**I feel less stressed**		
	I don't know	2	4%
	Strongly disagree	4	8%
	Disagree	3	6%
	Neither agree nor disagree	4	8%
	Agree	4	8%
	Strongly agree	1	2%

Q13	**I feel less unsuccessful**		
	I don't know	3	6%
	Strongly disagree	3	6%
	Disagree	3	6%
	Neither agree nor disagree	6	12%
	Agree	2	4%
	Strongly agree	1	2%

Appendix 7

Total number of respondents	49
Students who watched the videos	31

Compiled responses

	Number of respondents	Pecentage
What was the main reason you did not view the videos?		
I get the help I need	22	45%
I reach my goals in math without using the videos	19	39%
I forgot that I had access to the videos	19	39%
I rather ask the teacher than view the videos	18	37%
I rather ask a friend than view the videos	15	31%
I rather ask a parent/sibling than view the videos	13	27%
Math is easy	11	22%
I felt unmotivated to try the videos	10	20%
I didn't have time to view the videos	10	20%
I rather view other online videos than these videos	9	18%
I rather use another service than these videos	8	16%
Math is boring	7	14%
I feel unmotivated in math	6	12%
If I get stuck on an exercise I skip it	6	12%
A friend tried the videos and didn't like them	5	10%
I don't think I can understand with help from videos	3	6%
The videos seemed boring	3	6%
It was tedious to create an account	3	6%
Math is unimportant	1	2%

What would have made you view the videos?		
Before the national exams	23	47%
If it was more difficult to reach my goals in math	22	45%
Before a major test in my math course	21	43%
If my math course were more difficult	21	43%
If a friend would have recommended the videos	20	41%
If the teacher would have recommended the videos	16	33%
If I had waited for a long time to get help from the teacher	15	31%
If I had been reminded	12	24%
If I had more time	12	24%
If I had been more motivated in math	10	20%

Separate responses

Q1	**During class I usually get stuck on an exercise**		
	Never	1	3%
	Some time per week	12	39%
	Some time per class	14	45%
	Several times per class	4	13%

Q2	**I get the help I need**		
	Instämmer inte	2	6%
	Varken instämmer eller instämmer inte	7	23%
	Instämmer	15	48%
	Instämmer helt	7	23%

Q3	**During a regular week I study this much math outside class**		
	0 hours	10	32%

	0 - 2 hours	13	42%
	2 - 4 hours	7	23%
	4 - 6 hours	1	3%

Q4	**If I get stuck on an exercise I skip it**		
	Instämmer inte alls	3	10%
	Instämmer inte	15	48%
	Varken instämmer eller instämmer inte	7	23%
	Instämmer	5	16%
	Instämmer helt	1	3%

Q5	**I felt unmotivated to try the videos**		
	Instämmer inte alls	5	16%
	Instämmer inte	2	6%
	Varken instämmer eller instämmer inte	12	39%
	Instämmer	6	19%
	Instämmer helt	4	13%
	Vet inte	2	6%

Q6	**I forgot that I had access to the videos**		
	Instämmer inte alls	2	6%
	Instämmer inte	5	16%
	Varken instämmer eller instämmer inte	5	16%
	Instämmer	16	52%
	Instämmer helt	3	10%

Q7	**It was tedious to create an account**		
	Instämmer inte alls	6	19%
	Instämmer inte	10	32%
	Varken instämmer eller instämmer inte	4	13%
	Instämmer	2	6%
	Instämmer helt	1	3%
	Vet inte	8	26%

Q8	**I don't think I can understand with help from the videos**		
	Instämmer inte alls	14	45%
	Instämmer inte	8	26%
	Varken instämmer eller instämmer inte	1	3%
	Instämmer	2	6%
	Instämmer helt	1	3%
	Vet inte	5	16%

Q9	**The videos seemed boring**		
	Instämmer inte alls	9	29%
	Instämmer inte	6	19%
	Varken instämmer eller instämmer inte	6	19%
	Instämmer	1	3%
	Instämmer helt	2	6%
	Vet inte	7	23%

Q10	**A friend tried the videos and did not like them**		
	Instämmer inte alls	5	16%
	Instämmer inte	3	10%
	Varken instämmer eller instämmer inte	3	10%
	Instämmer	5	16%

	Vet inte	15	48%

Q11	**I feel unmotivated in math**		
	Instämmer inte alls	9	29%
	Instämmer inte	7	23%
	Varken instämmer eller instämmer inte	8	26%
	Instämmer	4	13%
	Instämmer helt	2	6%
	Vet inte	1	3%

Q12	**Math is boring**		
	Instämmer inte alls	9	29%
	Instämmer inte	8	26%
	Varken instämmer eller instämmer inte	7	23%
	Instämmer	5	16%
	Instämmer helt	2	6%

Q13	**Math is easy**		
	Instämmer inte alls	4	13%
	Instämmer inte	5	16%
	Varken instämmer eller instämmer inte	11	35%
	Instämmer	10	32%
	Instämmer helt	1	3%

Q14	**Math is unimportant**		
	Instämmer inte alls	18	58%
	Instämmer inte	11	35%
	Varken instämmer eller instämmer inte	1	3%
	Instämmer	1	3%

Q15	**I don't have time to view the videos**		
	Instämmer inte alls	4	13%
	Instämmer inte	6	19%
	Varken instämmer eller instämmer inte	11	35%
	Instämmer	8	26%
	Instämmer helt	2	6%

Q16	**I rather ask the teacher than view the videos**		
	Instämmer inte	6	19%
	Varken instämmer eller instämmer inte	7	23%
	Instämmer	10	32%
	Instämmer helt	8	26%

Q17	**I rather ask friends than view the videos**		
	Instämmer inte	8	26%
	Varken instämmer eller instämmer inte	8	26%
	Instämmer	11	35%
	Instämmer helt	4	13%

Q18	**I rather ask parents/siblings than view the videos**		
	Instämmer inte alls	2	6%
	Instämmer inte	10	32%
	Varken instämmer eller instämmer inte	5	16%
	Instämmer	6	19%
	Instämmer helt	7	23%

	Vet inte	1	3%

Q19	**I rather use other online videos than view the videos**		
	Instämmer inte alls	2	6%
	Instämmer inte	10	32%
	Varken instämmer eller instämmer inte	7	23%
	Instämmer	3	10%
	Instämmer helt	6	19%
	Vet inte	3	10%

Q20	**I rather use other services than view the videos**		
	Instämmer inte alls	3	10%
	Instämmer inte	11	35%
	Varken instämmer eller instämmer inte	6	19%
	Instämmer	4	13%
	Instämmer helt	4	13%
	Vet inte	3	10%

Q21	**I reach my goal in math without viewing the videos**		
	Instämmer inte	2	6%
	Varken instämmer eller instämmer inte	5	16%
	Instämmer	10	32%
	Instämmer helt	9	29%
	Vet inte	5	16%

Q22	**Before a major test in my math course**		
	Instämmer inte alls	2	6%
	Instämmer inte	2	6%
	Varken instämmer eller instämmer inte	4	13%
	Instämmer	17	55%
	Instämmer helt	4	13%
	Vet inte	2	6%

Q23	**Before the national exams**		
	Instämmer	17	55%
	Instämmer helt	6	19%
	Instämmer inte	1	3%
	Instämmer inte alls	3	10%
	Varken instämmer eller instämmer inte	2	6%
	Vet inte	2	6%

Q24	**If my math course were more difficult**		
	Instämmer inte alls	2	6%
	Varken instämmer eller instämmer inte	6	19%
	Instämmer	16	52%
	Instämmer helt	5	16%
	Vet inte	2	6%

Q25	**If I had more time**		
	Instämmer inte alls	3	10%
	Instämmer inte	8	26%
	Varken instämmer eller instämmer inte	6	19%
	Instämmer	6	19%
	Instämmer helt	6	19%
	Vet inte	2	6%

Q26	**If I had been reminded**		
	Instämmer inte alls	4	13%
	Instämmer inte	6	19%
	Varken instämmer eller instämmer inte	4	13%
	Instämmer	7	23%
	Instämmer helt	5	16%
	Vet inte	5	16%

Q27	**If I had been more motivated in math**		
	Instämmer inte alls	6	19%
	Instämmer inte	8	26%
	Varken instämmer eller instämmer inte	5	16%
	Instämmer	7	23%
	Instämmer helt	3	10%
	Vet inte	2	6%

Q28	**If it was more difficult to reach my goals in math**		
	Instämmer inte alls	1	3%
	Varken instämmer eller instämmer inte	4	13%
	Instämmer	14	45%
	Instämmer helt	8	26%
	Vet inte	4	13%

Q29	**If a friend would have recommended the videos**		
	Instämmer inte alls	3	10%
	Instämmer inte	4	13%
	Varken instämmer eller instämmer inte	2	6%
	Instämmer	13	42%
	Instämmer helt	7	23%
	Vet inte	2	6%

Q30	**If the teacher would have recommended the videos**		
	Instämmer inte alls	3	10%
	Instämmer inte	2	6%
	Varken instämmer eller instämmer inte	7	23%
	Instämmer	14	45%
	Instämmer helt	2	6%
	Vet inte	3	10%

Q31	**If I had waited for a long time to get help from the teacher**		
	Instämmer inte alls	3	10%
	Instämmer inte	8	26%
	Varken instämmer eller instämmer inte	2	6%
	Instämmer	10	32%
	Instämmer helt	5	16%
	Vet inte	3	10%