EXAMENSARBETE INOM TEKNIK OCH LÄRANDE,
AVANCERAD NIVÅ, 30 HP
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Students' and teachers' experiences of distance teaching of mathematics in Swedish upper secondary schools

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EXAMENSARBETE INOM TEKNIK OCH LÄRANDE PÅ PROGRAMMET CIVILINGENJÖR OCH LÄRARE

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Abstract

As technological advancements and improvements are made, the concepts of school digitalization and distance teaching become increasingly interesting and relevant. While distance teaching has existed for over a decade, it was not commonly practiced until the global pandemic 2020 where schools all around the world decided that teaching would be conducted remotely reduce the risk of spreading COVID-19. Sweden was one of these countries and decided that teaching in Swedish upper secondary schools would transition into being conducted at a distance. This master thesis focuses on students' and teachers' experiences of distance teaching in upper secondary school mathematics in Sweden during the years 2020-2022. The study is divided into two parts, one with a research purpose of examining how distance teaching has influenced students' and teachers' experiences of teaching and learning mathematics, and the other with the intent to create a support material in the form of a handbook to facilitate and integrate distance teaching in upper secondary school mathematics. Quantitative and qualitative data were gathered from 80 students using an online survey and nine interviews with three being with teachers and six being with students. The quantitative data were analyzed thematically to identify focus points and resulted in the focus of five different aspects of mathematics teaching - students' general work, student motivation, the possibility of receiving help from a teacher, classroom communication and classroom participation. The theoretical frameworks used were sociocultural theory and equivalency theory. Results from the quantitative data revealed that students' experiences of distance teaching were mostly negative with a very small amount noting positive experiences. A small but notable amount stated that distance teaching had no effect on their learning experiences. Qualitative findings revealed that the reason for the negative experience was that most students were dependent on external factors such as outer motivation, social interaction, teacher help and classroom communication. Students who were not negatively affected were self-regulating and whose studies and learning were independent of external factors. The development part of this study aimed at developing a handbook that could help schools implement and utilize distance teaching. The handbook was created through analyzing previous findings to identify challenges and difficulties with distance teaching that the writers could provide potential solutions for, and advice on, how to prevent. The initial prototype of the handbook was exposed to a limited form of testing due to upper secondary schools having transitioned back to traditional teaching at the time of the study. Therefore, the presented version of the handbook remains a prototype.

Keywords: distance teaching, mathematics, upper secondary school, student learning.

Sammanfattning

I takt med att tekniska framsteg och förbättringar görs blir digitalisering inom skolväsenden och distansundervisning alltmer intressanta och relevanta. Även om tillgängligheten till distansundervisning har funnits i över ett decennium, var den inte vanligt förekommande förrän den globala pandemin 2020 där skolor runt om i världen beslutade att undervisning skulle bedrivas på distans för att minska risken för spridning av COVID-19. Sverige var ett av dessa länder och beslutade att undervisning i svenska gymnasieskolor skulle övergå till att bedrivas på distans. Detta examensarbete fokuserar på elever- och lärares erfarenheter av distansundervisning i matematik på gymnasieskolor i Sverige under åren 2020–2022. Studien har två huvudsakliga syften, det första syftet är att identifiera hur distansundervisning har påverkat elever- och lärares upplevelser av undervisning av gymnasiematematik. Det andra syftet är att utveckla ett stödmaterial i form av en handbok vars syfte är att underlätta utförande och integrering av distansundervisning i matematikundervisning på gymnasieskolor. Det första syftet korresponderar till studiens forskningsdel och genomfördes med hjälp av kvantitativ och kvalitativ datainsamling genom 80 elev respondenter i en webbenkät och nio intervjuer varav tre var med lärare och sex med elever. Kvantitativa data analyserades tematiskt för att identifiera fokuspunkter och resulterade i fokus på fem olika aspekter av matematikundervisningen – elevernas allmänna arbete, elevmotivation, möjligheten att få hjälp av en lärare, kommunikation i klassrummet och deltagande i klassrummet. De teoretiska ramar som användes var sociokulturell teori och ekvivalensteori. Resultaten från den kvantitativa forskningsdelen visade att elevernas upplevelser av distansundervisning var mestadels negativ med endast en liten andel som noterade positiva upplevelser. En liten men anmärkningsvärd andel uppgav även att distansundervisning inte hade någon effekt på deras inlärning. Resultaten från den kvalitativa delen visade att orsaken till den negativa upplevelsen var att de flesta elever var beroende av yttre faktorer som yttre motivation, social interaktion, hjälp från läraren och klassrumskommunikation. Elever som inte påverkades negativt var självreglerande och vars studier och lärande var oberoende av dessa yttre faktorer. Det andra syftet motsvarar studiens utvecklingsdel. Handboken skapades genom att analysera resultaten från forskningsdelen för att identifiera utmaningar och svårigheter med distansundervisning. Sedan skulle potentiella lösningar och råd om hur man kan förebygga dessa utmaningar och svårigheter ges i handboken. Den ursprungliga prototypen av handboken genomgick en begränsad form av testning på grund av att gymnasieskolan vid studietillfället redan hade övergått tillbaka till traditionell undervisning. Därför förblir den presenterade versionen av handboken en prototyp.

Nyckelord: Distansundervisning, matematik, gymnasieskolan, lärande

Acknowledgment

We, Johannes and Suheib, have attended KTH for 6 amazing years and now with this final project it is coming to an end. Our study period has had its ups and downs and we have witnessed a world changing in front of our eyes, from technological developments to environmental issues all the way to the pandemic that marked these last two years. It has surely been an honor and a pleasure to study, learn, grow and develop into two fully scaled Masters of science & upper secondary school teachers and for that we would like to start with thanking KTH.

We want to continue with thanking people directly involved in this thesis, which has been all the wonderful students and teachers that participated in the study and shared their experiences of distance teaching with us. We would also like to thank our amazing supervisors Ernest Ampadu and Cecilia Kozma for guiding and helping us throughout the whole process of this thesis. We would like to thank our examiner Arnold Pears as well for participating in meetings and giving us clear requirements and feedback. And thank you to K-ULF for letting us write our master thesis as a part of the project.

Lastly we would like to thank our families who supported us throughout the process as we have been busy spending a lot of time on trying to make the best thesis we could, and we would also like to thank each other for a good cooperation. This has been a fun and very fruitful semester as we have gained a lot of useful and practical insight while working on this project. As we are leaving KTH we are both very excited for the future and what it holds for us.

We hope you enjoy reading this thesis,

Johannes Mejreh & Suheib Saleh

April 2022

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1. Introduction

In 2020, the world experienced a global pandemic that affected every part of the world, including school systems. According to UNESCO (2020), the closures of schools have impacted 94% of the world's student population, which corresponds to approximately 1.6 billion students throughout 192 countries. Sweden was among the 192 countries that decided in 2020, as a step towards reducing the spread of covid-19, to make upper secondary school education transition to conducting teaching at a distance (Folkhälsomyndigheten, 2020). Li and Lalani (2020) wrote about how schools all around the world both shut down and transitioned into distance teaching, as well as how teaching had been affected by such a change. Li and Lalani (2020) went on to discuss the effectiveness and aftermath of a transition to distance teaching. They mentioned the challenges of such a sudden transition. For example, only 34% of Indonesian students had digital tools such as computers available for school work. In the US, only a fourth of 15-year-olds with disadvantaged backgrounds had access to a computer for schoolwork, whilst almost all kids from a privileged background had access to one. These circumstances, among others, were in direct conflict with goal four of the United Nations (UN) sustainable development goals (SDGs), which states that inclusive and equitable quality education must be made available to children and students all around the world (United Nations, n.d).

The public school system in Sweden has been overseen by the government agency *The Swedish National Agency for Education*, in Swedish *Skolverket*, ever since its foundation in 1991. Since then, the school curriculum has changed twice, and in 2011 the current curriculum, Lgr11 (Skolverket, n.d.a) for primary schools and Gy11 (Skolverket, n.d.b) for upper secondary schools, was implemented. In Gy11, Skolverket presents its main values. Some of them include that the goal of education is to encourage learning and that education should be based on scientific grounds and proven experiences (Skolverket, n.d.b). Since the implementation of Lgr11 and Gy11, the curricula have been revised a couple of times to include digital competence. Skolverket has stated that a new curriculum, Lgr22, will be implemented for primary schools in July of 2022 (Skolverket, 2022a), but does not mention anything about a new curriculum for upper secondary schools. With no major changes to Gy11, the upper secondary school system in Sweden has remained unchanged since the curriculum change, until the global pandemic year 2020.

In Sweden, the pandemic only affected certain levels of education. Primary schools did not practice digital teaching in general, upper secondary schools had a hybrid system of both digital and physical classes, while university teaching transitioned completely to being carried out at a distance (Skolverket, 2020). Mwanza and Engeström (2005) wrote that a sudden change in the learning environment can affect student learning. With the sudden transition to distance teaching in Sweden, with virtually no preparation, studies such as Mwanza and Engeström can lead to concern regarding how teaching and student learning have been affected by the change. Researching how digital teaching has influenced student learning could turn out to be too difficult for one to study, as different subjects can have different benefits and drawbacks to being taught digitally. Several studies have been carried out in Sweden regarding the effects on student learning in upper secondary school mathematics during the pandemic. Strand and Thorén (2021) and Wahlström (2021) wrote about students'

experiences with digital mathematics teaching during the pandemic. However, very little is known when it comes to students' views on digital mathematics teaching after having experienced a transition to digital teaching and then back to traditional teaching. This master's thesis will therefore focus on the experiences of students that were part of these transitions and their experiences with digital mathematics teaching.

This study is done together with the practical research project *Kompensatorisk undervisning för lärande och forskning* (K-ULF), which translates to - Compensatory teaching for learning and research. K-ULF is a branch of the national pilot project *Utveckling, Lärande och Forskning (ULF)*, which translates to - Development, learning, and research. The project started in 2017 and was supposed to last until 2021 but was extended to 2024. The purpose of the project is to *"develop and test sustainable collaboration models between academia and school in terms of research, school activities and teacher education." (GU, 2020).*

1.1 Purpose of the study and research questions

This study has two key purposes, one research purpose, and one development purpose. The research purpose includes identifying how digital teaching has influenced upper secondary school students' experiences of mathematical teaching. This was done through gathering and studying various data. The development purpose includes creating support material, in the form of a handbook, designed for teachers to facilitate student learning in a mathematics classroom. This will be done through the identification of the potential benefits and drawbacks of digital teaching.

1.1.1 Research questions

To answer and meet the purpose of the study, the following research questions are used:

- What are upper secondary school teachers' and students' experiences of distance teaching of mathematics during the pandemic?

- How can a prototype of support material, in the form of a handbook, be designed for teachers and schools to facilitate and integrate distance teaching in upper secondary school mathematics?

1.2 Limitations of the study

The limitations of this study were various, but the two main limitations are that the study only studied students in upper secondary school and only upper secondary school students' experiences with the mathematics subject. The reason only upper secondary school students were studied is since primary school students in Sweden did not fully transition into digital teaching while the upper secondary school students did. The reason for choosing mathematics as a subject is due to it being a core subject for all upper secondary school students and one of the challenging subjects for most students and therefore it will generate both a larger and

wider amount of data. Another reason for choosing mathematics is that the authors of this study are specialized in mathematics teaching and learning at the secondary level.

Furthermore, there was an additional limitation on the selection of students that were studied. The limitation was that only second and third-year students were studied. This is since first-year students, at the time of this study, had not experienced distance teaching while the second-and third-year students had. The study will cover the years 2020-2022. However, note that the semester of spring 2022 is ongoing at the time of writing this study and is not finished like the previous ones.

2. Background and theory

In this section, relevant background information and previous studies about distance teaching will be presented, followed by the theoretical perspectives that will permeate this study and finally a presentation of different theories regarding mathematics teaching.

2.1 Distance teaching

Distance teaching is a type of teaching or learning that is defined by a geographical distance between the student and teacher. Skolverket (2022a) defines it as interactive teaching using information and communication technology (ICT), but without the teaching needing to be in real time. This form of teaching is possible with most subjects except for and esthetical subjects, where being in the same space is necessary (Skolverket, 2022a). In this study, the term *distance teaching* refers to teaching that is conducted through participants sharing time but not geographical location, meaning that the participants used a digital tool that allowed them to share a virtual room, such as a digital meeting platform.

With the sudden transition to distance teaching in upper secondary school education in Sweden, teachers and students were faced with challenges. Studies dating back to before COVID-19 have documented difficulties and challenges with distance teaching in mathematics. For example, Smith and Ferguson (2005) studied dropout rates for various courses being taught at a distance. The results show that the dropout rate of mathematics courses was significantly higher than the dropout rate of non-mathematic courses being taught at a distance. A similar study was done by Heppen et al. (2017). The study included a mathematics course given both online and traditionally. Results show that the students that studied at a distance performed worse and were more likely to drop out in comparison to the students that studied traditionally.

Hrastinski (2008) wrote about how online learning environments can be split up into two different types, one being *asynchronous learning* and the other being *synchronous learning*. Asynchronous learning is defined as learning environments where students and teachers do not necessarily share the same time. It could be a course website where course content in the form of videos, documents and assignments are available for students to access at any given time. This sort of learning environment was especially beneficial to students that had other commitments such as work and families and could only study when free time arose. The free and flexible nature of asynchronous learning was therefore almost crucial to some students. Synchronous learning was the opposite of asynchronous learning. It was defined as learning environments where teachers and students share time, meaning that they can be in videoconference or chat rooms together. Due to the time-sharing aspect of synchronous learning, it was experienced as more social and less frustrating as questions can be asked and answered in real time. Hrastinski went on to discuss the futility of trying to label one learning environment as superior to the other due to both having their own benefits and limitations. Instead, the focus should be shifted to when, why and how one of the two can be optimally used. The argument was further supported by the fact that the nature of a tool can be either synchronous or asynchronous depending on how it is used. For example, an asynchronous tool such as e-mail can be as synchronous as a chatroom if the two users stay

logged on and reply instantaneously. Hrastinski in his analysis of when, why, and how to use asynchronous or synchronous e-learning established the following table:

Table 1: When, Why, and How to Use Asynchronous vs. Synchronous E-learning

Table 3

When, Why, and How to Use Asynchronous vs. Synchronous E-Learning

	Asynchronous E-Learning	Synchronous E-Learning
When?	■ Reflecting on complex issues ■ When synchronous meetings cannot be scheduled because of work, family, and other commitments	■ Discussing less complex issues ■ Getting acquainted ■ Planning tasks
Why?	■ Students have more time to reflect because the sender does not expect an immediate answer.	■ Students become more committed and motivated because a quick response is expected.
How?	■ Use asynchronous means such as e-mail, discussion boards, and blogs.	■ Use synchronous means such as videoconferencing, instant messaging and chat, and complement with face-to-face meetings.
Examples	■ Students expected to reflect individually on course topics may be asked to maintain a blog. ■ Students expected to share reflections regarding course topics and critically assess their peers' ideas may be asked to participate in online discussions on a discussion board.	■ Students expected to work in groups may be advised to use instant messaging as support for getting to know each other, exchanging ideas, and planning tasks. ■ A teacher who wants to present concepts from the literature in a simplified way might give an online lecture by videoconferencing.

Source: Hrastinski. (2008)

The table shows Hrastinski's findings. Benefits of asynchronous e-learning environments seem to be that they are beneficial when tutors want students to reflect more on assignments and course content related questions. This was due to students not experiencing as much of a time limitation when having to come up with answers. There was however a downside to this, which is that if students do not meet face to face to discuss and only experience asynchronous e-learning environments, they miss out on collaboration and feeling a part of a community which are crucial for their learning. Synchronous e-learning environments were shown to be beneficial when looking at social and motivational aspects. Discussions were more frequent and casual, however the quality of answers given to questions as well as the difficulty of the questions were lacking as there is a sort of quantity over quality valuation when having to give quick answers to keep discussions alive. This did however have motivational benefits as people are more likely to ask questions as they know they are more likely to receive an answer. To categorize, Hrastinski (2008) associated the benefits of asynchronous e-learning with what he called *cognitive participation*, which include the ability to reflect and process information while synchronous e-learning was linked to *personal participation* which includes aspects such as arousal, motivation and more frequent but less complex communication.

Hrastinski et al. (2010) noted that synchronous e-learning needed guidance and in their study carried out evaluations of four different design exemplars for synchronous e-learning. Findings of the study showed that no exemplar could be deemed as optimal for carrying out synchronous e-learning. Instead, which exemplar was deemed more useful was dependent on factors such as relations in the classroom, which digital media was used and how understandable and usable these media were for the teacher. They further noted that a simple introduction of digital tools was insufficient, the teacher had to properly learn how to use these tools.

Bryceson (2007) in his analysis of distance teaching also established the weight of social interaction in the classroom. Bryceson stated that online teachers experienced difficulties creating an environment where students engage in their learning which can lead to difficulties finding and achieving student's ZPD. Bryceson therefore advocated that a primary requirement for a good online learning environment is the use of a tool that allows for and facilitates group communication. This was further advocated by Hamann et al. (2012) as the findings of their study were that students have trouble asking questions, engaging in discussions, and finding participation in online lectures interesting.

2.2.1 Previous research on distance teaching globally

Smith et al. (2002) studied tutor experiences of college courses being taught at a distance. They observe that distance teaching did have benefits such as promoting equality in the classroom, however distance teaching was still incomplete, and the challenges were various. The biggest issue being that the communication between tutor and student was limited which in turn led to further troubles such as students not being able to play an active role in their learning. Another consequence of the paucity in communication was the absence of students feeling a classroom community which reduced the opportunities for deeper discussions in the classroom.

Safavi et al. (2013) studied high school mathematics being taught both at a distance and traditionally with the purpose of comparing the two teaching methods to see if one of the two was superior or potentially lacking. The study showed that students who experienced traditional teaching achieved higher results than students being taught through digital- and distance methods. Safavi described one potential reason for the difference in effectiveness being that students who were being taught digitally did not feel that they were part of a student community and the classroom discourse thereby being limited due to students feeling inhibited.

2.2.2 Previous research on distance teaching in Sweden

Sveriges Elevkårer, one of Sweden's largest youth organizations, carried out a study in April of 2020 where members of the organization, who were upper secondary school students, answered a survey about their experiences with distance teaching (Sveriges Elevkårer, 2020). The survey was available between the 14th and 20th of April, during that period the survey gathered 7543 answers. The Swedish government decided that upper secondary school education would be carried out at a distance on the 17th of march, therefore the answers were given by students with approximately one month's experience of distance teaching. While 80% of students answered that the distance teaching was "going okay" or better, the complaints were many. Students experienced that the communication in the classroom was severely lacking and getting help from the teacher was more difficult, took longer time and was less effective. Several students commented that they had learning difficulties and some diagnoses which made learning at a distance even more difficult. Some of the comments also mentioned that the motivation was lacking due to the shift in environment and that they miss socializing with their classmates.

Åkerfeldt and Hermansson (2020) studied Swedish upper secondary school students' experiences with studying mathematics at a distance. The study included answers from 2306 students that had experienced distance teaching anywhere between five to eight weeks. Survey questions were used to gather data and the questions mainly focused on comparing teaching climates. Results show that most students experienced disadvantages in the distance teaching climate in comparison to traditional teaching climates. A question asking the students what sort of teaching they preferred shows that 56% of students wished to go back to traditional teaching while 20% wanted to continue distance teaching and 24% did not have a preference. The biggest differences between the climates seemed to be in student focus, motivation, and social aspects. Students that prefer traditional teaching said that it was due to the change in social aspect. When asked about how available teachers were in respective climates, student answers indicate teachers being less available for help during distance teaching. The students mentioned that it was more difficult to get help from the teacher in distance teaching and that the social aspects of traditional teaching were a motivating factor in their studies. This can also be seen in a question that was asked in the survey about how lonely students felt, the results show that a significantly higher portion of students felt lonely when studying at a distance. When studying answers from students that prefer distance teaching, Åkerfeldt and Hermansson noticed that these students seemed to have it easier to focus when studying alone at home while a significant part of students that wished to go back to traditional teaching mentioned difficulties focusing and staying motivated when studying at home.

Sohl (2020) interviewed eight Swedish upper secondary school mathematics teachers with the purpose of identifying different ways that mathematics teachers planned distance lectures. Sohl also studied if the teachers structured the lectures in a way that would promote cooperation between students. Results of the study show that not many teachers took student-cooperation into account when planning lectures. One of the teachers said that he/she promoted cooperation in different courses, but not in mathematics. Two of the teachers mentioned that they have students with diagnoses and other difficulties that benefit more from studying alone. Several teachers said that even though they did not actively promote student-cooperation, the students would take their own initiatives to work together. However, four out of the eight teachers said that they sometimes used oral examinations in smaller groups where the students would present their solutions to each other.

Molin et al. (2020) carried out a study about distance teaching in Sweden and in their study viewed the issue of students not turning on their camera and microphone. Results showed that while distance teaching worked well for students whose motivations are high and are driven, downsides are many for students who lack motivation. One major problem was the availability to turn their camera and microphone off during lectures and go do something else. This problem was furthermore a difficult one since students' home environments can differ and potentially lead to some students not wanting to turn on their camera and/or microphone.

2.2 Theoretical standpoint

The theoretical standpoint for this project is Lev Vygotsky's sociocultural theories about human learning. The main theme of this theory is that learning and cognitive development is found in social interaction and environment. Vygotsky referred to two levels of learning, first one is interpsychological which is learning through interaction between people, then afterwards

intrapsychological which means that this learning is integrated in the individual herself (Vygotsky, 2005).

There are some central terms or ideas that this project will use from Vygotsky. The first one is **artifacts**. An artifact is a tool used in interaction between people and between humans and their world. Wartofsky (2012) presents three levels of artifacts. The primary artifacts are physical objects used to interact with the world and produce the means or tools for existence. Examples of primary artifacts are knives, bowls, glasses, and axes. The secondary artifacts are psychological and used to interact with other people. It preserves and transforms skills or knowledge in the production of primary artifacts through some sort of communication, for example language, symbols, or rituals. The tertiary artifacts transcend anything concrete and practical and can be defined as imaginary and relatively autonomous. An example of a tertiary artifact is art.

The next one is called **mediation**. To mediate is to convey and transfer information. This can be done through cooperation between humans and cultural artifacts. Vygotsky (2005) says that the knowledge process can be seen as a mediation. There are three types of mediation. The first one is mediation as a form of regulation. Regulation means to control activity or a process, in this case it is the process of learning. The second one is mediation by artifacts, which refers to humans mediating their psychological activity through artifacts. The simplest example is communicating through language. The third type of mediation is mediation through gestures. This means that an individual is communicating with the help of hand movement and body language. (Mustafa et al., 2019)

The third central term in Vygotsky's theory is **"the proximal development zone" (ZPD)**. This is the zone between where a child can learn alone and where that same child can learn but through assistance of some form, for example from a teacher. Vygotsky means that through this potential development given the assistance needed, later the child will be able to do it alone (Vygotsky, 2005). Shabani et al. (2010) means that if you give the child interesting, meaningful, and slightly difficult problem-solving tasks, the child will have to cooperate with other peers or seek assistance from a teacher to be able to fully solve the problem. This will take the child to the next level and their ZPD will be raised. Repeat this process again from that level to the next and so forth to encourage learning through this theory.

2.2.2 Equivalency theory

Simonson (1999) wrote about distance teaching and theories about this dynamic and ever-changing educational form. There had been a lack of strong theories that could uphold the subject and in which both research and practice could be based upon. Usually, these theories emphasize the fact that local teaching and distance teaching are fundamentally different and hard to bridge. Most approaches on distance teaching have therefore been based on trial-and- error methods, with little consideration given to theory. Simonson (1999) continued with, what was at his time, more recent studies that were based on newer technology and new potential interactive capabilities. This contradicted the previous fact that the space between distance and local teaching was hard to bridge.

From these discussions emerged a theory called the equivalency theory, which is defined as: "*Distance education's appropriate application should provide equivalent learning experiences*

for all students - distant and local - in order for there to be expectations of equivalent outcomes of the educational experiences". Distance teaching, even with interactive technology, will still be different to local teaching because they operate in different environments, as the previous theories have stated. But the difference here is that the distant educator will create, probably different teaching events, but that has equivalent learning outcomes as local teaching. Simonson likened this theory to a square and a triangle that have equivalent area, but obviously different forms (Simonson, 1999).

2.2.3 Other theories

The theories of Jean Piaget (2013), a Swiss development psychologist, were often concerned with the nature of knowledge and how we acquire it. He meant that we construct knowledge in this world through interaction with it. This is called constructivism which is another of the main perspectives in pedagogy. A key concept in this is cognitive development, which Piaget meant is a progressive process that depended on biological and environmental development. An adult is an individual that builds systems and theories, thinks, and reflects freely and abstract while a child doesn't have systems and only thinks concretely with what is given to them. The changing point from a child to adult is around the age of 12 according to Piaget.

Another perspective, closely associated with communication and feedback, is behaviorism. Skinner (2008) wrote about how student learning mainly happens when students encounter feedback from a more knowledgeable figure, such as a teacher. According to Skinner, the student will show behaviors that the teacher will have to reinforce or punish. Through this stimulus-response interaction, different behaviors are either encouraged or discouraged. Previous studies, described earlier, highlight how distance teaching limits the student-teacher interaction and how students miss out on these situations where different behaviors can be encouraged or discouraged.

2.2.4 Choosing a theoretical framework

The theoretical framework for this study will be the sociocultural perspective as described by Vygotsky (2005) and the equivalence theory as described by Simonson (1999). The main reason for choosing a sociocultural perspective over a cognitivist or behavioristic one is due to the change in the classroom environment and communication that follows distance teaching according to similar previous studies (Smith et al., 2002; Safavi et al., 2013; Sveriges Elevkårer, 2020; Åkerfeldt and Hermansson, 2020). As this study aims at understanding the consequence of this change and how it affected students' and teachers' experiences of mathematics teaching, the choice of theoretical framework therefore relied on which theory was deemed most relevant to the change in classroom environment and communication. The change regarded social and communication aspects of the classroom, which are vital pillars in sociocultural theory and is the main reason behind the decision of the main theoretical framework. The choice of equivalence theory was based on how this study will view potential difficulties with distance teaching that have led to a difference in learning outcomes and provide potential solutions to these difficulties that will aim at an equality between the two forms of teaching.

2.3 Teaching mathematics

Mathematics and teachings of the subject have existed for thousands of years and looking at history, you can see the evolution of mathematics and society going hand in hand. With how digitized the world is today, mathematics could be seen as one of the pillars of our world. In the Swedish syllabus for upper secondary school mathematics, emphasis is put on not only teaching students mathematical models, methods, and formulas but also how to communicate mathematics and understanding its role in society (Skolverket, n.d.c).

Skolverket (n.d.c) concretizes six different mathematical abilities or competencies that mathematical teaching should give students the opportunity to develop:

- The ability to use and describe mathematical concepts
- The ability to solve mathematical tasks with and without tools
- The ability to analyze and solve mathematical problems
- The ability to apply, formulate and evaluate mathematical models
- The ability to conduct and follow mathematical reasoning
- The ability to communicate mathematics.

The division of mathematical competence into different subgroups is quite common and another popular division is done by Skott et al., (2010) that described eight different mathematical competencies. These eight competencies are further split into two categories: *To ask and answer within, with and about mathematics*, and *to be able to handle the language and tools of mathematics*. The following table contains the different competencies under corresponding category:

Table 2: Skott et al.'s mathematical competencies

To ask and answer within, with and about mathematics	**To be able to handle the language and tools of mathematics**
Thinking-competence *(ability to develop a relevant thought and express it)*	Representation-competence *(ability to manage different mathematical representations)*
Problem management-competence *(ability to find, formulate and solve mathematical problems)*	Symbol and formalism-competence *(ability to decode mathematical symbols and formulas)*
Modeling-competence *(ability to analyze and build mathematical models)*	Communication-competence *(ability to interpret and discuss mathematics that others present)*
Reasoning-competence *(ability to reason mathematically)*	Assistive-competence *(ability to utilize mathematical formulas and tools)*

Skott et al. (2010) described mathematical learning with the help of two categories. *Learning as appropriation,* where the focus lies on internal learning and how students assimilate new knowledge and *learning as participation* where the focus lies on the social aspects of teaching

such as communication, interplay with teachers and classroom participation. The easiest way to differentiate between the two would be to remember that within learning as appropriation, to properly communicate mathematics, you must learn mathematics, while within learning as participation, to properly learn mathematics you must participate in the communication of mathematics (Skott et al., 2010). During distance teaching, in order for the teaching to be equally beneficial for students, the same learning circumstances have to be present (Simonson, 1999). This means that, taking Skolverket and Skott et al.'s mathematical competencies and their importance into consideration, there must be equal opportunity for students to develop these for distance teaching to be viewed as equal.

2.3.1 Mathematics didactics

Wahlström (2016) wrote about teaching mathematics and five didactical questions to take into consideration when trying to teach mathematics. The five questions are:

1. What is the goal of the teaching?
2. Why should the teaching take place?
3. Who is supposed to learn this?
4. Which tools are needed to carry out this teaching?
5. How will the teaching take place?

Wahlström (2016) further described a didactical triangle that can be used as a blueprint for how to view didactics and the main pillars of it which are - *learner, teacher,* and *content*, in this case mathematics. These pillars are included in a general *context* which can for instance be the classroom and together create what Tchoshanov (2013) referred to as a *cultural system*. The didactical triangle is presented in the following figure:

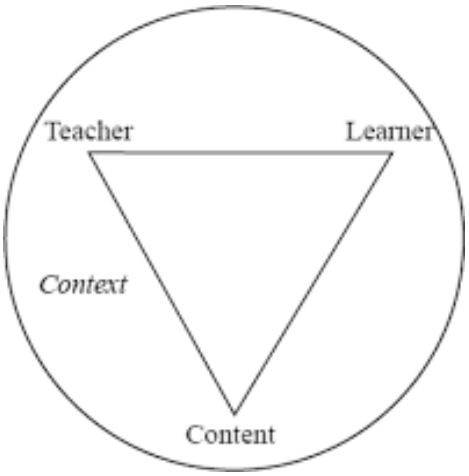

Figure 1: The didactic triangle

Wahlström (2016) wrote that the relations in the didactical triangle are important for teaching and learning and can be seen in three steps. First, the introduction of a mathematical content which is the relation between teacher and content. Then, the mediation of this content which is the relation between teacher and learner. Finally, the learning experiences of the learner to the content which is the relation between those two. The didactical triangle can also be

compared to the interpsychological to the intrapsychological process as Vygotsky (2005) stated but instead with content as an actor itself.

Today, technology has entered the domain of teaching, especially during the years 2020-2022 because of the global pandemic. Tchoshanov (2013) concludes that the modification of the didactical triangle is inevitable as technology advances and becomes more relevant. When technology is added as a pillar the didactical triangle turns into the didactical tetrahedron according to the following figure:

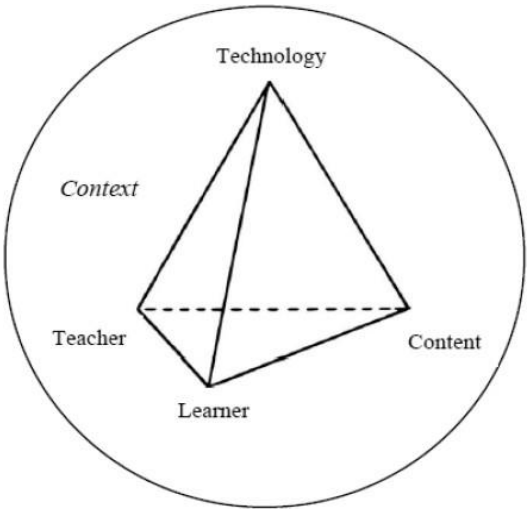

Figure 2: The didactical tetrahedron

The bottom face of the tetrahedron is the relation teacher-learner-content which is the traditional didactical triangle proposed by Wahlström (2016). However, the remaining sides of the tetrahedron are also triangles and can be viewed as representations of relations which are adaptable into distance teaching and can be used as a blueprint in the digital world of teaching. Tchoshanov (2013) defined the relation learner-content-technology by using Mitra's (2005) definition of *e-Learning* as *"a self-organized learning model in a virtual environmen*t", as it concerns the relation between the student, mathematics, and the technological tool. The next relation in the tetrahedron is teacher-content-technology which Tchoshanov (2013) defined as *e-Teaching* and concerns the relation between the teacher, mathematics and the technological tool. It is the same as e-Learning but instead of learning, it concerns teaching in a virtual environment. The last relation is teacher-learner-technology which concerns the interaction between the teacher and the student in a virtual environment, beyond the subject matter. Tchoshanov (2013) defined this as *e-Advising*. Just as the didactical triangle is dependent on all three of its pillars for teaching to work in a traditional classroom (Wahlström, 2016), the didactical tetrahedron is dependent on not only the didactical triangle but just as importantly on e-Learning, e-Teaching, and e-Advising as well (Tchoshanov, 2013).

2.3.2 Communication in learning

Skott et al., (2010) continued discussing the concept of communication, its role and importance in mathematics teaching as well as how different tools of communication such as

symbols and representation models, can be used to facilitate mathematical learning. A parallel is drawn between the communication and social norms that arise consequently, which are crucial for developing learning possibilities in the classroom. Norms that arise from the communication between teacher and student are part of how students view their involvement in the teaching and their learning. These norms are however not only dependent on teacher-student communication but also communication between students in the form of discussions. The discussions between students can be vital for their learning as students tend to reflect more when they view the discussion being between two *equals* instead of with a peer who knows more, to which they tend to accept what is said without much reflection. These norms further affect aspects in teaching such as how students view questions and how willing students are to ask and answer different questions in the classroom (Skott et al., 2010).

Maltén (1998) wrote about how the communication between two people is more than just an exchange of information but also of values and attitudes, especially in a social interaction between student and teacher where the teacher can be viewed as a peer or a leader. Maltén (1998) wrote about *coding* and *decoding* in social interactions and means that in a social interaction, you do not just listen and speak but try to understand and differentiate between what is said and what is meant. The use of feedback in communication is crucial when trying to decode intended meaning. For example, through questions such as “So you mean…?” and “Did I understand you right if I understood that as…?”, the communication becomes more focused on the meaning behind words that are said. Encouraging communication is a responsibility belonging to the teacher due to his/her role as a leader in the classroom and in the students' learning. It becomes up to the teacher to create a classroom environment where asking questions is encouraged, however it is not always that easy (Maltén, 1998; Skott et al., 2010).

Bennett (2010) touched on communication in a classroom from a child psychological point of view. He claimed that the outspokenness and willingness to ask questions in a class of adolescent students is dependent on social aspects. Bennett referred to Canfield and Wells' (1976) metaphorical explanation of *the poker chip theory*. This theory states that students who experience academic success possess more poker chips and in contrast students with less academic success possess less poker chips. Consequently, the students with more chips are more willing to take risks such as participating interactively while the students with lesser chips feel like they have more to lose and are taking a bigger risk of looking intellectually poor in front of their classmates. This results in less interactive participation from them and in turn a slowed down learning process.

Bennett (2010) continued to mention that to gain more chips the students will need to experience more academic success. This is seemingly a closed cycle where the amount of chips and the academic success are dependent on each other. However, Bennett also noted that students who are more reluctant to interact in bigger groups usually feel more comfortable discussing in smaller groups. The problem with creating and using smaller groups is time consumption. As it is practically impossible for a teacher to be able to listen and interact with several groups at a time, the use of smaller groups can in some cases be counterproductive (Benett, 2010). Bennetts statement about the classroom culture can be linked to what Zimmerman (2019) and Wernersson (2010) described as how some classrooms can experience an *anti-study-culture*.

Studies carried out on distance teaching show that one of the biggest changes in the classroom is the social aspect. Student interactivity lessened and this is explained as due to students feeling less motivated and interested due to not meeting their classmates and friends (Sveriges Elevkårer, 2020; Åkerfeldt and Hermansson, 2020). However, these seem to be students that are already familiar with their classmates and teacher and have built a social connection to them, but what about students that transitioned from primary school to upper secondary school and joined a new class on distance? These students could be even more vulnerable to the poker chip theory that Bennett (2010) discussed as their classmates will most likely be strangers. In such an environment where it is more difficult to get to know someone and become friends, something like a high social status is difficult to establish and the risk is therefore higher that more students will be more reluctant to answer questions according to the poker chip theory.

2.3.3 Motivation

Illeris (2015) stated that motivation is a very important part of learning and describes it as consisting of a combination of students' feelings towards a certain learning-situation and their predetermined will and attitude towards learning. He further wrote about the changes between what a student is capable of learning, which can be affected by external factors such as teachers and environments, and what a student is willing to learn, which is affected by internal factors such as will, attitude and insecurities. This distinction between an inner and outer is also mentioned by Deci and Ryan (2000) who wrote that motivation can be split up into intrinsic (inner) and extrinsic (outer) motivation. The inner motivation is described as motivation that is completely independent of acknowledgement from external factors such as teachers, feedback, and rewards but rather from a pure feeling of will and interest in doing and/or learning something. The outer motivation is described as an opposite, it is motivation that is derived from external factors such as feedback, rewards and even punishments. These motivations are intertwined, and a certain amount of motivation is needed from the student to complete tasks and achieve results, if not enough inner motivation is present there is the need for it to be complemented by outer motivation. Motivation that starts off as outer motivation can lead to the development of inner motivation; however, the opposite can also be said. Exposing a student to negative results, feedback and punishments can lead to a reduced inner motivation (Deci & Ryan, 2000; Klapp, 2015; Amabile, 1993).

Which of the two forms of motivation is more beneficial depends on the circumstances of the situation. When discussing a situation where students are supposed to learn, inner motivation has shown to outweigh outer motivation in the long term (Lei, 2010). This is due to what the student becomes motivated towards and how he/she achieves the sense of accomplishment that follows their effort. Inner motivation promotes learning as the student becomes more self-reliant, willing to learn and put in effort, and drawbacks can be focusing too much on what is interesting and thereby ignoring the intended outcome or result. Outer motivation helps the student re-achieving whatever it was that which gave the student the outer motivation or not, for example a high grade, praise, or other positive results. Drawbacks of outer motivation can be low self-esteem, dependence of frequent rewards and too much focus on achieving specific results instead of the intended path to achieve the result. This focus on results can lead to shallow learning and minimalistic effort to achieve a specific result. Therefore, the teacher's role in student motivation is to control where the outer motivation comes from. Instead of

focusing on achieving results, the teacher should create a classroom environment with particular emphasis on the path to achieving certain results aim at enhancing the continuous work and learning of the individual student (Ayub, 2010; Lei, 2010; Klapp, 2015).

2.3.4 Assessment

Assessment is an integral part of the teaching and learning process. Klapp (2015) wrote about two different types of assessment - summative and formative. Summative assessment is a summation of the students' knowledge on the subject, for example the total points collected at a major exam at the end of a course. This is one way of assessing what the students have learned although the arguments against this as the sole method of assessment are plenty. However, summative assessment is necessary for the educational system. It is the only way to decide who progresses from one level to the next systematically.

The second way of assessing is formative assessment which usually is recommended together with summative for the best possible outcome. Formative assessment refers to the continued assessment of the students' knowledge throughout the course, that is formative assessment is the continuous process of assessing students learning using different reflective assessment procedures. This is made for instance through smaller and multiple tests where the students receive direct and concrete feedback and can develop themselves continuously. Usually grades and points are excluded in formative assessment and the focus is solely on helping the student learn and develop. The difference is according to Klapp (2015) that summative assessment is often described as assessment *of* learning while formative is described as assessment *for* learning.

There is a direct correlation between students' assessment score and other aspects of their learning processes. For example, when teachers assess and grade a student's work, it can affect more than just the summative result. It can go deeper and affect a student's motivation and interest to learn more as a teacher can help students progress in their work and experience less difficulty studying the subject which motivates them to study more. Klapp (2015) recognizes this difficulty and therefore advocates for a more formative teaching and assessment philosophy but at the same time admits that it is a complex approach and hard to adapt to if the teacher already works in a more traditional teaching culture. Similarly, Oyedeji (2017) notes the difficulty in the continuous feedback that is included in formative assessment, as much of it will have to happen in classroom and lecture environments which can lead to reduced participation and motivation by students. This reduction is due to a fear of giving the wrong answer and looking bad in front of their classmates.

2.3.5 Teaching mathematics online

When teaching mathematics online, the teacher will need to use digital tools one way or another, but the use of these digital tools should complement rather than compromising the use of the available physical tools. Nyström and Trygg (2020) shared a story, fictional but based on reality, about a teacher who used a website to examine whether the students had learned anything from the previous chapter of their mathematics course. The teacher constructed questions on the program and let her students answer them. Afterwards, the

program showed different charts and stacks with the answers to each question where the teacher could clearly see lacking knowledge in a general sense. If one area was particularly difficult for the students, for example the correct-answer rates were low, then the teacher would start the next class with revising that area before moving on to new content.

Three things can be derived from this. First is the possibility to examine whether your students have learned anything and therefore have another chance to repeat certain areas. For the students this can also be seen as an opportunity to summarize previous learnings without fearing grade assessment, which is beneficial for the future exam. Secondly, the use of digital tools was maybe not necessary, but possibly a more interesting way to make this exercise, according to Nyström and Trygg (2020). Thirdly, this story showed that digital tools do not have to be complicated, they could act in beneficial ways for teaching mathematics using something as straight forward as traditional survey questions.

Loch (2008) found in their study of mathematics teaching at a distance that integrating distance teaching into mathematics can be beneficial for students that are motivated, disciplined, and willing to learn. However, they saw a negative effect on students that are less motivated and do not review lecture material beforehand or even attend lectures. Engelbrecht and Harding (2009) similarly stated that students that lack discipline and willingness to engage in their mathematics learning can encounter even greater difficulty learning and studying at a distance due to having the increase in their own responsibility of their learning. Dalland and Kettle (2016) supported this in their study of self-regulated learning as their study found that an increase in responsibility that follows self-regulated learning in mathematics can lead to reduced learning. Another study done by Dalland and Kettle (2014) showed that when given assignments, higher motivated students tend to quickly finish the assignment while lower motivated students tend to procrastinate and finish at the deadline.

Mupinga (2005) described benefits and challenges with distance teaching and what sort of students this form of education benefits. According to Mupinga, students who prefer distance teaching usually enjoy flexibility of study schedule and the time that they save from not having to commute to the school or institution. Mupinga further found that the groups of students that benefit from distance learning are rural students, gifted students, students who have problems in regular classrooms, students with financial considerations, family, or work obligations, sick or hospitalized students and traveling students. In addition to this, decreasing opportunities of socialization and personal interaction is usually the major challenge. Other challenges include training teachers for the digital environment, defining the corresponding workload for each teacher and inserting motivation in the student’s that are not self-going nor fond of studying from a distance. However, if the logistics of distance teaching is handled then this form of education can also be a suggested solution to large school enrollments.

3. Method

In this section, the method used to conduct the study will be discussed. The chapter is divided into six sub-sections; the first section discusses the general work progress that is used. The second section examines the way of gathering information and this is followed by the way of collecting the necessary data for the study. The fourth section examines the analysis of the data, and the last section presents the ethical considerations that the researchers adhered to in conducting the research.

As previously mentioned, this study was done in collaboration with K-ULF. In addition to working with K-ULF, the researchers of this study were assigned two supervisors that helped the researchers and guided them throughout the whole process of researching, planning, writing, and developing. Through regular meetings with the supervisors where the researchers presented progress and changes made, a stable and continuously regulated workflow was established and maintained.

3.1 General work progress

The general work progress plan was inspired by the work of Strand and Thorén (2021), who carried out a similar study together with K-ULF and followed Lilliesköld and Eriksson's (2005) project model. The project model consists of three main *project-phases* and based on the purpose of the study and finding answers to the research questions, the current study is guided by the sequential transformative mixed-method research design (See Figure 3 and Section 4.1). The first phase is called the *start phase* and includes planning and discussing what the study will be about and how it will be carried out. The second phase is the *implementation phase* which consists of carrying out the plan that was discussed in the start phase, often focusing on the gathering of data. The third and final phase is the *concluding phase* which consists of documenting and analyzing the gathered data and development (Lilliesköld & Eriksson, 2005).

In this study, the start phase consisted of establishing the main workspace, a preliminary work plan and the research questions. The chosen workspace was Google Drive, where every document and file related to the study would be stored. This workspace was chosen due to the availability aspect that Google Drive provides for everyone involved. The researchers, supervisors, and the examiner all always had full access to the files. Communication between researchers, supervisors and examiner were mainly made through email and Zoom-meetings. Whenever significant progress was made, the researchers would email the supervisors to set up a zoom-meeting where they would present and discuss the progress. In the start phase, the originally established time and work plan and research questions were honed and it was further decided what methods of data gathering would be carried out to best answer the research questions. The methods that were decided upon were surveys and interviews. The surveys were used to gather mainly quantitative data with some qualitative, then interview questions would be established through thematic analysis on the gathered data and finally interviews would be carried out to gather more in depth qualitative data. Before moving on to the implementation phase, it was decided that a pilot study would be carried out to evaluate preliminary questions in the survey.

The implementation phase of the study consisted mainly of gathering data. Surveys were sent out to gather quantitative data and after gathering enough answers the data was thematically analyzed to form interview questions and a general interview-guide that were followed in the interviews. The interview questions for students and teachers differed slightly but both were aimed at the respective parts experience with distance teaching in upper secondary school mathematics. While awaiting answers to the surveys, the researchers carried out a literature study where theories and previous research about relevant subjects were studied and documented in the background section (See section 2).

The concluding phase of the study consisted of compiling, documenting, and analyzing all of the gathered data from both the surveys and the interviews. The quantitative data was viewed in statistics but also individual answers to try and identify trends between answers given to different questions. The interview questions were formed in such a way through thematic analysis, that they would help the researchers investigate trends and better understand the different experiences. To discuss and answer both the research part and the development part of the study, the data was interpreted and analyzed with the help of previously presented theories and studies. Finally, the results, analysis and discussions were documented in each respective section (See section 5 and 6).

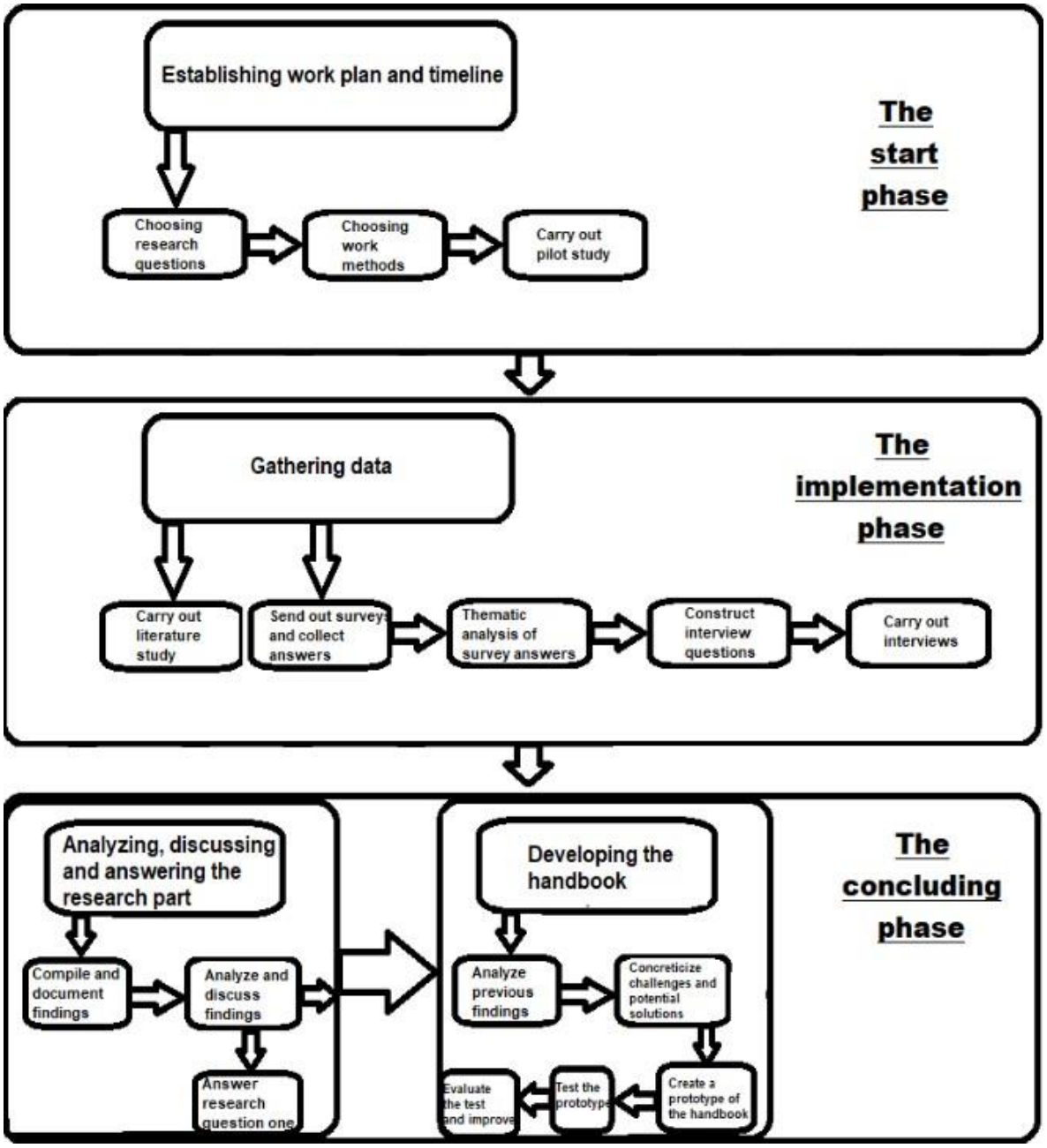

Figure 3: The work phases

3.2 Gathering of information

The gathering of information can be split up into two parts, as shown in Figure 3. The first part being reading, studying, and writing about previous theories and studies regarding relevant subjects (See section 2). The second part would be the data gathering which consisted of sending out surveys and holding interviews. Both parts were done during the implementation phase of the study. The researchers wanted to see a larger picture of how student experiences are but also be able to dive deeper into why students experienced what they did. To do this, the researchers decided to approach the study with *mixed methods*. The quantitative method was the use of the survey to get statistics on student experiences, however the survey included both closed and open questions. The questions on the survey were decided with the help of a pilot study. Since the researchers wanted to create interview questions based on a thematic

analysis of the results from the surveys, they decided to give the students the possibility to motivate their given answers on the survey.

3.3 Data collection

Bjørndal (2005) wrote about observation which he defines as *concentrated monitoring.* From a pedagogical standpoint this is a professional skill that an observer can hone. Among some of the aspects an observer should have or can develop is theoretical knowledge, specific knowledge of usual sources of error and better knowledge and skills of different observational methods. Observation is a form of data collection. However, in this study, direct observations on a class were not made. Instead, two other methods of gathering data were used which were surveys and interviews. Bjørndal (2005) referred to these two as an excellent complement to observation. While constructing a survey or questions for an interview the observer should still have all these aspects previously mentioned, to observe the data that will be collected in the best possible way.

3.3.1 Selection

Three main selections were made in this study. The first being to only study upper secondary school students and teachers' experiences. This selection was made due to the reason that primary school students continued with their teachings through traditional methods, while upper secondary school students transitioned completely to distance during a semester. The second main selection was to only study second and third year upper secondary school students' experiences. This selection was made due to the reason that the study was carried out during the first quarter of 2022, which means that first year students at upper secondary school had not experienced any distance teaching. The third main selection was deciding which students and teachers were going to be interviewed. The selection of which students to interview was three students that prefer traditional teaching over distance teaching and three students that prefer distance teaching over traditional teaching. This selection was done with the hopes of being able to identify trends or patterns between students that prefer physical and distance respectively. The selection of which teachers to interview was three teachers that had been teaching upper secondary school mathematics for a couple of years prior to the global pandemic and continued to teach upper secondary school mathematics during the global pandemic. This selection was made in hopes of receiving the experiences and opinions of a more experienced teacher that had more to base their opinions on. The surveys were sent out to teachers in nine different schools, of which only teachers from six different schools circulated the surveys to their students. In all, 80 students completed the survey and this was followed up with six student interviews and three teacher interviews from five different schools.

Table 3: Background information

	Number of students	**Number of teachers**	**Number of schools**
Surveys	**80**	**0**	**4**
Interviews	**6**	**3**	**5**

3.3.2 Survey

Bjørndal (2005) wrote about surveys as a method of gathering information. One of the biggest advantages with surveys is the quantitative possibilities, meaning it does not take a huge amount of time to manage and process. The answers are already written down and it can be conducted in a mass amount as opposed to interviews where one must take the time to sit down with all the interviewees. The drawback is the limitation in qualitative information.

Bjørndal (2005) named three essential criteria when constructing survey questions:

- The respondents should be able to understand the words of the survey questions. Bjørndal stressed the importance of being careful with what words are being used, especially if the respondents are children.

- The respondents are receiving sufficient information so that they can answer the relevant questions. For instance, to answer questions about health requires the information of time frame i.e. this morning, last week, over a month etc.

- The respondents need to know in which description or in what type of scale they are answering the questions. For instance, a scale of 1-10 on how they feel on a matter, or an open space to describe freely.

There are also three general forms of survey constructions. Number one being, as mentioned earlier, a survey with open space to answer freely. This allows for somewhat more qualitative and nuanced answers, at least in the lane of surveys. The second form of surveys have already made out answering options which is quicker and makes it easier in the event of comparison. The third and last form is a hybrid of the former two, meaning a question initially has already made answering options so one can secure the statistics and then right after there is an open space for the respondent that wants to add extra thoughts, giving more insight on the statistics. (Bjørndal, 2005)

There are five usual sources of errors in surveys that are important to be aware of, especially in the case of survey forms with already set answer options. These are:

- *The answer options do not match the question*. For instance, asking a “How many times…” question and having the options “many” and “few”. Instead, the answering options should be specific numbers or intervals to choose from.

- *Answers that are not mutually exclusive*. Asking “How old are you?” and having age brackets that overlap between each other as answering options for example “13-18” and then “18-25”. This will make the 18-year-olds confused and it will affect the results as they will randomly choose one.

- *Unrealistic answering options*. When the options are unrealistic it can make respondents not take it seriously and feel like they are wasting their time.

- *Answering options that are not covering enough*. Sometimes a respondent can feel like none of the answering options reflect their feelings or opinion on the matter. This

can partly be solved by adding a “do not know” or “other” alternative with an empty space for the latter as an opportunity to explain further.

- *Unbalanced answering options.* If one has unbalanced answering options with for instance more positive than negative alternatives then it will affect the results biased to the positive side. In other words, if there is a “very good” alternative then a “very bad” should be available as well.

Most of these sources of error can be avoided or heavily reduced by conducting a pilot study or a test investigation. (Bjørndal, 2005)

In this study the researchers have chosen to construct the survey questions often with a combined element of multiple choice questions and open spaces. The researchers first carried out a pilot study with 23 questions. These questions were inspired by a combination of how previous studies and theories stated that distance teaching affected mathematics learning, and how the importance of the different effects according to the sociocultural and equivalency theories. Almost all of the questions on the pilot study were of the multiple-choice form, meaning students would answer most questions by choosing an alternative. The pilot study was thereafter sent out to two teachers to share with their classes. The students answered the pilot study digitally on Google Forms.

After having received approximately 20 answers, the researchers proceeded to analyze the answers to see what needed to be altered to subsequently create the real survey. The main thing that was altered was that after each answering-option question, an additional open-answer question was added where students could motivate their previous choice. Additionally, some of the questions were modified in the way they were formulated. With these changes, the real survey reached a total of 29 questions (see Appendix 2) including the question of consent. The researchers calculated that this new survey would take approximately 15 minutes to answer, depending on how much information the respondents decided to write on the newly added open-answer questions. This survey was sent out in the same manner as the pilot but on a bigger scale to more schools and more teachers.

3.3.3 Interviews

Interviews are a way of gathering and presenting information, according to Bjørndal (2005). The biggest advantage that interviews have is that the interviewer can see details that normally would have been overlooked. In an interview the observer can read body languages and signs to potentially understand perspectives and thoughts more in depth. The disadvantage of an interview is that it can take more time to prepare, conduct, analyze and potentially transcribe. For this reason, this study is limited to fewer interviews, 6 students and 3 teachers more specifically. Another potential disadvantage is that the interviewer can affect the information or lean it towards an answer if not carefully conducted. However, in this study questions were formulated in a neutral and open-ended manner to avoid potential influence on interviewees. For example, a question like “Were your experiences of distance teaching of mathematics negative?” could potentially influence the interviewees answers and were instead formulated in the following manner: “What were your experiences of distance teaching of mathematics?”. Furthermore, to minimize the potential effect of the researchers' biases, the reflexivity method was used where the researchers only reported the exact responses of the interviewees.

Bjørndal (2005) wrote about 4 different forms of interviews that stretch from one end being low degree of structure to the other end being high degree of structure. In order from the lowest to the highest are the following forms of interviews:

- *Conversational interview* - this is the most open and unstructured form of interview. There is limited planning and both parties can steer the interview to whichever direction they want. Advantages of this form of interview are that new, rich, and unexpected information can come up continuously while the disadvantages are that since information can vary from person to person it will be harder to compare answers.

- *Conversation with the help of an interview guide* - The second form of interview is slightly more structured than the first. Here the interviewer has a detailed overview over themes and questions that he/she wants to touch on. However, there is still a lot of flexibility where the interviewer can change the order of questions and ask follow-up questions. This gives the perfect balance between keeping an open space to be able to gain new and interesting information as well as in depth understanding of the interviewee and still maintain focus on the themes that the interviewer wants to explore.

- *Standardized interview with open questions and answers* - The difference between the third form of interview and the previous is that the standardized interview consists of already fixed questions that will be answered in order. There is also no room for follow-up questions. However, the interviewee can still answer the questions freely. This is a more controlled form of interview which allows the previous disadvantage of comparing answers to be possible. The new disadvantages include higher risk of lacking clarity in the questions if not formulated well and chances of negatively affected ambiance between the parties if the interview is perceived more as an interrogation.

- *Standardized interview with fixed answering options* - The highest form of structure and control in interviews is the one with fixed questions and fixed answering options, which means no other answers than the alternatives they have is possible. The standardized forms of interviews are more reminiscent of a survey, only with an individual present to ask the questions. The biggest advantage is reliable comparison between answers and the biggest disadvantage is that in depth answers will not be registered, making this more of a quantitative mission than qualitative.

In this study the researchers used the *conversation with the help of an interview guide* form. This form was chosen so that the researchers can allow new and qualitative information to arise while also sticking to the topic with an overview of questions as the basis. The researchers formulated the first draft of the questions after analyzing the answers from the quantitative study (the survey) and looking for patterns and themes that were interesting to study more in depth. The questions were carefully formulated so that they do not give away or lean towards a biased opinion, often using “how” in the questions and encouraging the interviewees' own thoughts. Afterwards, the questions were revised, and a second draft was created and used as the overviewing basis when interviewing the teachers and students.

There were a total of 15 questions (see Appendix 6) for both teachers and students, the questions for the respective groups differed slightly but had the same purpose of asking about

their experiences of distance teaching. The researchers interviewed one person at a time and both researchers were present at every interview. The interviews lasted between 11-23 minutes, and they were transcribed the same day they were conducted. Furthermore, the interviews were recorded with cell phones if physical and through zoom if digital. This allowed for the researchers to transcribe it accurately.

3.4 Ethical considerations

The ethical principles in this study were followed in accordance with what the Swedish Research Council (2017) described as the four main ethical requirements in research.

1. *The information requirement* stated the necessity for the researchers to inform the study participants of the study itself and of the conditions of their participation. This study met this requirement as the participants were informed about what the study is about, why it was done, that their participation in the study was completely optional and that they had the right to withdraw their participation at any given time. This information was given both in the surveys and in the interviews.

2. *The consent requirement* stated that the researchers must obtain the participant's consent. If the participant is under the age of 15, the consent must be obtained from the participants legal guardian. The participants must also have the right to choose to withdraw their consent at any given time and if this is done, no negative consequences or undue pressure should follow. This requirement was met as the first question in the survey was a question where the respondent (participant) chooses whether he/she consents to participating in the study. In the interviews, participants were given a consent form containing information about the study and their participation that they signed to give consent to participate in the study. The students and teachers that were interviewed were all over the age of 16 and therefore, consent from a legal guardian was not needed in this study. Participants were also informed that they had the right to withdraw their consent at any given time and they were given the contact information of both researchers so that they may do so if they wished (See Appendix 5).

3. *The confidentiality requirement* stated that any information about the participants that could lead to identification of the participant is to be documented, stored, and handled with the greatest possible confidentiality such that it would be practically impossible for an unauthorized person to have access to it. This requirement was met as no information that could be used to identify a participant is mentioned in the study and every document and form that is somehow related to the study was in a google drive that only the researchers, their supervisors and their examiners had access to. The participants were also informed that when the study is finished, all material related to the interview will be handed over to KTH's storage services, where the material is stored, and a confidentiality check takes place before any documents are given out. Finally, participants were informed that KTH is responsible for the processing of the personal information given in the consent form of the interviews.

4. *The utilization requirement* stated that the information gathered from and about participants may only be used for research purposes. This requirement was also met as the gathered information was and will only be used to better answer the studies research questions and for authorized members of K-ULF to use in future research articles. This was also communicated to the participants.

3.5 Method of analysis

Following the collection of the relevant data for the study, an analysis of the data is to be pursued. In this chapter the analysis will be separated into two categories - the quantitative and the qualitative data analysis. The quantitative analysis refers to the analysis of statistical results from the survey while the qualitative analysis refers to analysis of the open-answer questions on the survey and the interviews.

3.5.1 Quantitative data analysis

The quantitative data were in the form of statistics through questions that were of the multiple-choice form. The statistics were presented in the form of a pie chart with different colors representing different choices. The survey questions and the charts that came from the answers were both originally written in Swedish, however the questions and results were translated to English before being written into the study. The quantitative results were presented in the form of the charts as this is a good way of seeing an overview or a general conclusion of the questions (Bryman, 2011).

3.5.2 Qualitative data analysis

The qualitative data consisted of student answers to open-answer questions on the survey and answers to interview questions that were designed and asked by the researchers. The interviews were conducted orally and recorded, thereafter a transcribing was done for each interview to transform the recorded data to written form. Furthermore, the interviews were conducted in Swedish, however quotes from the transcripts that are used in the study were first translated into English before being written in the study. This data included, in comparison to the statistical data from surveys, a more in-depth description of how the respondents think. The survey also included some questions with an open space answering area where the respondents could respond with their own words, giving room for deeper understanding of the statistical answers they had given.

Braun & Clarke (2006) wrote about thematic analysis which is a method of analysis that aims to identify, analyze, and report patterns and themes of certain data. Thematic analysis is widely used as a qualitative analysis tool; however, it is poorly branded as a method as there is no clear definition and way of doing it. Braun & Clarke have however organized 6 phases of thematic analysis. The first phase is *familiarizing yourself with your data*. This starts at the transcription, as it is being written down it counts as the first read through of the data. The researchers thereafter re-read the transcription and noted valuable information. The second phase of thematic analysis is to *generate initial codes* of the data through a systematic approach. In this phase a collation of the data to each code is being made. The third phase is *searching for themes*. Here, the researchers are collating the codes into potential themes. The fourth phase is *reviewing the themes*, in other words the researchers are checking that the

relevant themes work well with the codes, reviewing the entire data and creating a “thematic map” of the analysis. The fifth phase is to *define and name themes*. All the themes that came up in the search and the reviewing needs to be defined and named and it is in this step. It is also the step of refining the overall story the analysis tells. The sixth and last phase is *producing the report*. In this phase the last opportunity of analysis can be made, reviewing all the extracted themes, and selecting the ones that will help produce a scholarly report of the whole analysis, relating back to both research questions and literature.

3.6 Method of designing the handbook

This section will describe in detail the chosen method for dealing with the development part of the study and answering the second research question (See section 1.1.1). Stiftelsen Svensk Industridesign (SVID) described a design process for developing and optimizing a product (SVID, n.d.a) and this design process was chosen as the main inspiration for the chosen method. The choice was made due to the design process being deemed as extensive by the researchers due to the inclusion of analyzing difficulties, creating a prototype, and testing the prototype to create an improved version. SVID’s design process consists of 5 different phases or steps which are *understanding, defining, idea generating, prototyping, and testing and implementing* (SVID, n.d.a). This design process was not strictly followed but instead chosen as an inspiration to create 4 similar steps which are:

Steps

1. Analyze findings and identify difficulties
2. Analyze identified difficulties to find and concretize challenges
3. Find potential solutions and creating a prototype of the handbook
4. Test and improve the handbook

The first step in designing the handbook was to thoroughly analyze the findings from section 6 to be able to understand the needs of the students and teachers during distance teaching. This is important to avoid the risk of developing something that is not of need for the users (SVID, n.d.b). The findings were analyzed by firstly identifying challenges and difficulties that students and teachers mentioned in each of the five aspects and then organizing them in a list to see what the general needs were.

The second step consisted of further analyzing the previously created list to find similarities and connections between difficulties and challenges. This would lead to concretized challenges that the researchers then present potential solutions to. The similarities between different challenges and difficulties were found by analyzing what the students needed and how the challenge or difficulty limited the providing of these needs. These needs were identified in accordance with the method of *problem formulation* that SVID (n.d.d) described.

In the third step, potential solutions to the concretized challenges were found. To do this, the researchers followed the methods of *changing perspective* (SVID, n.d.e). The change of perspective was done by changing perspective into that of a traditional classroom to understand why these challenges do not exist during traditional teaching and present a solution that can be integrated into distance teaching to combat and prevent the challenge. Thereafter, a prototype of the handbook was created with an introduction section, a

background section covering how the prototype was made, a challenge section with the different challenges that were studied and an advice section with potential solutions in the form of advice. The list of advice was listed separately to teachers and to schools.

The fourth and final step in the design process was to test the created prototype. The testing of the prototype was done by sending the prototype to the three interviewed teachers and receiving feedback on potential benefits and limitations of the handbook. The teachers were asked to make this evaluation by evaluating how beneficial they perceived this handbook would have been if it was available during their transition to distance teaching at the start of the pandemic. The feedback that was received was used to fill out the *test your idea* (SVID, n.d.f) template (see Appendix 3) that SVID provides. With the help of the template, the researchers could use the feedback to reflect on and adjust the content of the prototype to make an improved version (see Appendix 1).

4. Study design

The following section describes the design of the study. The section mentions and discusses details regarding how the researchers carried out the previously described methods (See section 3). The section starts by describing the research design and why it was chosen and then discusses aspects of data collection, such as the selection of participants and the data collection procedure. Lastly, the section ends with subsection 4.4, where the data analysis procedure is described.

4.1 Research design

This study draws upon the sociocultural and equivalency theories as the study's main theoretical perspectives to help achieve the aim of the study and also answer the research questions guiding the study. These theoretical perspectives suggest that the classroom discourse is complex and cannot be investigated from any single theoretical perspective (Clarke, 2002). Clarke further added that the nature of the social settings where we conduct our research is multifaceted and this calls for the adoption of a research methodology and design that offers a voice to participants through the use of different data collection and analysis procedures. The research design for this study is inspired by the definition of *sequential transformative mixed-methods research (STMM)* that Creswell (2003) provides. Different researchers use mixed-methods designs for different reasons and there is a plethora of literature regarding the reason why researchers adopt mixed-methods designs.

For this current study, the purpose of using a mixed-method design is underpinned by the views of Gay et al. (2006) who argued that mixed-method design "build on the synergy and strength that exists between quantitative and qualitative research methods in order to understand the phenomenon more fully than is possible using either quantitative or qualitative methods alone" (p.490). Similarly, the choice of the mixed-method design was to help provide a better understanding and insight into the research problem and the questions than the researchers could have gotten using a single approach (Creswell & Clark 2007). To better understand what it means for research to follow a STMM design, the term could be split into two parts: mixed-method and sequential transformative.

- The mixed-method part regards studies that use both quantitative and qualitative methods when for example gathering and analyzing data (Creswell & Plano, 2007).

- The sequential transformative part regards studies that first decide on theoretical perspectives and then carry out the gathering and analyzing of quantitative and qualitative data in a manner that best serves the theoretical perspective (Creswell, 2003).

As highlighted above, this study followed STMM by first choosing the sociocultural and equivalency theories as the study's main theoretical perspectives. Afterwards, the researchers decided on how data would be gathered and analyzed. By studying previous studies and theories on distance teaching both globally and in Sweden, the researchers identified several aspects of mathematics teaching that could potentially be affected by mathematics teaching being carried out at a distance.

To identify which of these aspects were relevant in this study, a general picture of student experiences was needed regarding the effect distance teaching had on said aspects. Therefore, it was decided that the mixed-method of data gathering and analysis would be carried out by first sending out a survey with closed questions to gain statistical results that would give the researchers a general picture, followed by qualitative data gathering in the form of interviews that focus on the relevant aspects revealed by the quantitative findings. However, as interviews are time-consuming, it would not be possible to carry out enough interviews to collect a broad variety of qualitative data on student experiences. Therefore, the surveys also included some open-ended questions where students could elaborate their previous answers and experiences of distance teaching. As the gathering of qualitative data through interviews was informed by the results from the analysis and results from the quantitative (survey) we can say that the research design for the current study is underpinned and inspired by the STMM. This is so because the survey instrument had both closed and open-ended questions which were analyzed concurrently. However, the collection of the qualitative data from the interviews was influenced by the results from the initial quantitative data.

4.2 Criteria for selecting participants

The criteria for selecting the study participants were that they had to be second or third year upper secondary school students or upper secondary school teachers. As previously mentioned, both surveys and interviews were used for collecting the data for this study. Regarding the selection of participants for the first phase of the study, as this study was made in collaboration with K-ULF, the researchers held frequent communication with the teachers in K-ULF and when it was time they simply sent out the survey to those teachers. The teachers could subsequently send the survey out to their upper secondary schools in the Stockholm region and ask their students to answer the survey. No consideration for the students' specialization was made. As long as they were second or third year students they were eligible to participate. In all a total of 80 students from different schools within the Stockholm region completed the survey.

Regarding the interview participants, the researchers wanted to find other teachers than the ones that were accessible through K-ULF as they were too close to the study. The researchers therefore used a purposive sampling technique to select the students and teachers to be interviewed. That is for the interviews, the researchers physically went to upper secondary school number 1 (see appendix?) to interview the first teacher. After the interview, the researchers presented the project for the class that the teacher managed and asked if there were any free volunteers for an interview. After receiving one student who preferred traditional teaching, the researchers balanced it out by asking the class if there's anyone who instead preferred distance teaching. This way, the researchers found a student who preferred distance teaching. This process was repeated again in the following schools that the researchers visited. A total of two teachers and four students were found this way.

There were also some interviews conducted online. For this, the researchers first emailed a teacher in an upper secondary school in Stockholm about the project, in which the teacher agreed to participate. After the interview, the researchers asked the teacher if there are any

interested students that want to participate in the study from his/her class. The teacher asked his/her class the following day and when a student expressed interest he/she was connected to us by email. The researchers subsequently organized an online interview with the student. There were a total of two student interviews online. The second one was found by asking the first student if he/she knows of any other potential participants.

4.3 Data collection procedure

The data collection procedure of this study started after the analysis of pilot study answers which led to modified survey questions. Several questions were modified, few were removed and several were added. The new survey questions were then written in a Google Forms to construct the official survey that would be sent out to upper secondary school teachers. The official survey was sent out to five upper secondary school teachers within K-ULF during the last week of February 2022. Four out of the five teachers agreed to assist and distribute the surveys to their students resulting in a total of 80 responses during the third week of March 2022.

The quantitative data was planned to consist solely of statistical results from multiple-choice questions on the survey, therefore, the quantitative data collection was now complete. An analysis of the quantitative findings was then done to identify common factors in student experiences and decide on focus points for the interview. From this analysis, interview questions were constructed and put together into an interview-guide containing questions. Two separate interview-guides were constructed, one consisting of interview-questions intended for upper secondary school students and one intended for upper secondary school teachers. The interview-guides consisted of 15 primary questions with the possibility of follow-up questions from the researchers, in comparison to the surveys that consisted of 29 questions.

After having constructed the primary interview-guides, the researchers sent out emails to five upper secondary schools in Stockholm to ask for teachers and students willing to participate in the interviews. Four out of the five upper secondary schools agreed to assist, and three teachers were chosen from three different upper secondary schools to interview. Two out of the three teacher-interviews were conducted physically, and one was conducted digitally through the digital communication platform Zoom. The physical interviews were planned one hour prior to a lecture in mathematics with second year students so that the researchers could visit the lecture and ask if any students were willing to participate. This resulted in four student-interviews consisting of three students that preferred traditional teaching and one student that preferred distance teaching. In order to achieve the intended balance of interviewing three students that prefer traditional teaching and three teachers that prefer distance teaching, the researchers emailed three additional upper secondary schools in Stockholm. This resulted in the last two student-interviews being carried out digitally through Zoom.

4.4 Data analysis procedure

After collecting 80 responses to the survey, the quantitative part of the data was analyzed statistically. This was done by studying the different responses (pie-charts) that were automatically created in Google Form. The responses represented a general picture of student answers on each question percentage wise against the answer choices. The different parts of the pie chart (See Appendix 4) represent each answer choice and were presented in different colors to easier differentiate between. By studying the different pie charts provided for each question, the researchers were able to narrow down the focus point of the study to the five categories that provided the results showing a notable general effect of distance teaching. The categories were general work, motivation, receiving help from a teacher, classroom communication and classroom participation. The questions about these five categories along with the general question about preference of teaching form were the ones finally presented in the report in section 5.

The qualitative data, which was collected both from the open-ended questions in the survey and from the individual interviews, was analyzed thematically. The researchers first organized all the data after it had been gathered and read through it thoroughly to ascertain the different experiences from the respondents. The interview data were transcribed to generate common codes and categories. With the five main categories in mind, the researchers categorized the data in codes to be able to more easily find the relevant data. These codes were subsequently translated into different themes which would be the major and minor challenges presented in the development part (See section 6). The researchers then reviewed the themes in accordance with the data in order to see if the identified themes and categories were the best described and most inclusive themes possible. Lastly, after the reviewing and thorough analysis of the data, the researchers concreticized the themes as challenges that would serve as the basis for the handbook.

Furthermore, the theoretical perspectives were used during the thematic analysis. The themes and codes used in the thematic analysis were inspired through the use of priori categories from social constructivist theory, which includes *knowledge is constructed, constructing meaning, learning is an active process, learning is a social activity, learning is contextual, knowledge is personal, learning exists in the mind, and motivation is key to learning* (Vygotsky, 2005). From these, the researchers chose learning is an active process, learning is a social activity, learning is contextual, learning exists in the mind and motivation is key to learning, as a basis for studying and thematically analyzing the qualitative data. The comparison of students and teachers' experiences before and after during the pandemic, was then examined using the equivalence theory. The usage was underpinned by the predetermined assumption that learning experiences, regardless of whether the learner is in a traditional or distant setting, should be equivalent. This was a basis for identifying challenges and coming up with potential solutions.

The thematic analysis started by looking at the learning experiences of the three categories of students (Students who preferred distance teaching, students who preferred traditional teaching and students who had no preference). Firstly, the researchers studied the qualitative data from each of the categories individually to identify common factors between students in the respective categories. Students who preferred traditional teaching expressed minimal motivation to study during distance teaching. Students who preferred distance teaching showed an improved ability to plan their studies during distance teaching and students who had no preference were indifferent to the change of environments. Secondly, the researchers studied why these differences exist. The researchers examined how the five categories (general work, motivation, receiving help from a teacher, classroom communication and classroom participation) are related to the different experiences of students and saw that the key element of the differences was the reliance on external factors. Students who preferred traditional teaching noted a reliance on external factors while students who preferred distance teaching and students who had no preference did not rely on external factors. Thirdly, the researchers studied the reliance of external factors to see what students were potentially missing during distance teaching. The main external factors identified had to do with factors such as teacher assistance, interaction in the classroom and formative assessment. Lastly, the researchers studied the circumstances of distance learning and how a difference in circumstances between distance and traditional learning could result in limitations of the identified factors. This resulted in the identification of major and minor challenges with distance teaching (See Table 4 in Section 6.3).

5. Results and analysis - Research

This section of the study will include a presentation of results from the surveys and the interviews as well as how the results can be linked to the literature and previous studies presented in section 2. The first research question of this study (See section 1.1.1) covers the research part and was regarding students' and teachers' experiences of distance teaching in upper secondary school mathematics. In answering the first research question, we look at five different aspects of mathematics teaching. The chosen aspects are general work, motivation, receiving help from a teacher, classroom communication and classroom participation. The quantitative data is taken from the answers to multiple-choice survey questions and the qualitative data is taken from the open answer questions from the surveys and the interviews.

5.1 Distance vs traditional teaching

To understand students' preferred form of teaching, students were asked to pick their preferred form of teaching on the survey. The results are depicted in the graph below.

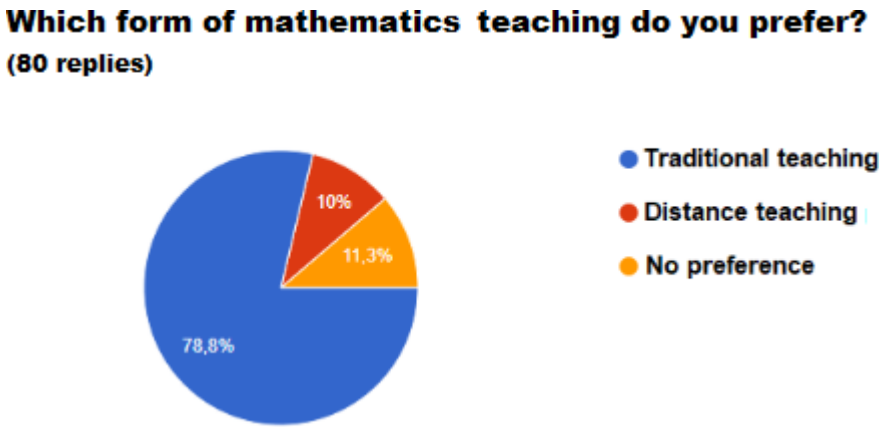

Figure 4: Swedish upper secondary school students preferred form of teaching

The quantitative data show that when students were asked in the survey about which form of teaching they prefer, out of 80 respondents, 65 (78.8%) preferred traditional teaching, 8 (10%) prefered distance teaching and 9 (11.3%) had no preference. These results are in line with previous studies about student experiences with distance teaching which showed that most students prefer traditional teaching (Åkerfeldt & Hermansson, 2021; Strand & Thorén, 2021). Furthermore, these results show that you cannot necessarily view one form of teaching as superior to the other as students will have their own preferences and could benefit more from one than the other. However, due to a large majority of students preferring traditional teaching, one must be mindful when trying to implement and integrate distance teaching as this preference may be a result of decreased teaching and learning for the large majority of students. It is also interesting to note that some 11.3% had no preference and this calls for critical analysis of how to support all students now that distance teaching and other forms of online teaching has become part of our school system.

In addition to the results from the quantitative data, analysis of the qualitative data from the open-answer question on the survey show that students that previously answered that they preferred traditional teaching gave reasons such as that it was increasingly difficult for them

to study, find motivation, listen during lectures, and receive help from the teachers during distance teaching. For example, survey student 46 wrote:

> *"Easier and smoother for the teacher to solve tasks, explain and introduce something on a board. The technology sometimes crashes, which makes the studies more difficult. Also requires much more discipline to sit at home and study, there are many more distractions, and it is easy to find yourself in bed."*
> *- Survey student 46*

Students that previously answered that they prefer distance teaching gave reasons such as that the quiet home environment was good for studying, focusing was easier and that they saved time due to for example not having to travel to school, which is in alignment with what Mupinga (2005) described as benefits for distance teaching. For example, in analyzing our qualitative data, we realized a common trend and survey student 4 reported his/her experienced benefits of distance teaching:

> *"1) Saves so much time - by not having to get to school and back. 2) Subjects like math can usually be done at home as it is your own work and if you need help, the teacher is online + that lectures are just as good online. 3) It is much easier to work in an environment that you are comfortable with (quiet, nice, is not disturbed by other students or when the teacher helps other students). 4) You get attendance when you are in the lesson but that does not mean that you actually work - the idea that you get attendance just because you are in the lesson but not working, makes no sense. I can be present at school and not work, but I will not get attendance if I am at home and actually working efficiently. 5) Students who have social anxiety may feel more comfortable working from home. 6) Less transport time also means that we students get more sleep - which benefits us enormously for both focus and concentration."*
> *- Survey student 4*

In addition to the qualitative data from the open-ended questions in the survey, six students were interviewed. The interviewed students that prefer traditional teaching gave similar reasons to that of the survey students that prefer traditional teaching. They found it more difficult to focus, work, find motivation, receive help from the teacher and there were more distractions at home during distance teaching. The interviewed students that prefer distance teaching gave reasons such as it is easier to focus as it is quieter at home compared to the lively classroom environment and it saves a great amount of time due to no travel and this is consistent with the findings from Mupinga (2005) and other researchers.

As indicated in the methodology section, in addition to the students' interviews, three teachers were also interviewed to ascertain their views regarding distance teaching and how this has or may have influenced students' learning experiences. The results show that all the three teachers were of the view that the preferred mode of teaching is dependent on the individual student. Teachers stated that it depends on the student but if you look at a classroom, then traditional teaching is more beneficial as most student's learning suffer from distance teaching as student motivation was generally lower and it is harder for teachers to know which students to encourage as you cannot see what they are doing and how their work is going. These results are in line with the quantitative data which in turn is in line with what Illeris (2015) described as a potential downside to distance teaching and Bryceson's (2007) theory on how

decreased interaction between teacher and student affects the student's ZPD (Vygotsky, 2005). The quantitative data and the qualitative data both seem to indicate a mostly negative experience of distance teaching for both students and teachers.

An analysis of qualitative data indicated that the only notable difference between students who preferred distance teaching and students who had no preference, was that students who preferred distance teaching stated that they saved time due to no longer having to travel to school and that they could structure and plan their studies easier. A separate question on the survey was regarding how students experienced that distance teaching affected their performance in mathematics (See Appendix 4) and 60% answered a negative effect, only 6,3% answered that they preferred distance teaching noted a positive effect on their performance. Further analysis of quantitative data show that only half of students who previously answered that they preferred distance teaching noted a positive effect on their performance while the other half noted no effect. These findings imply that not only did more students experience disadvantages than advantages of distance teaching, but also that the disadvantages were also more detrimental to students' learning than that the upsides were beneficial.

5.2 General work

To better understand their preference, students were asked how distance teaching affected their general work in upper secondary school mathematics. The results are depicted in the graph below.

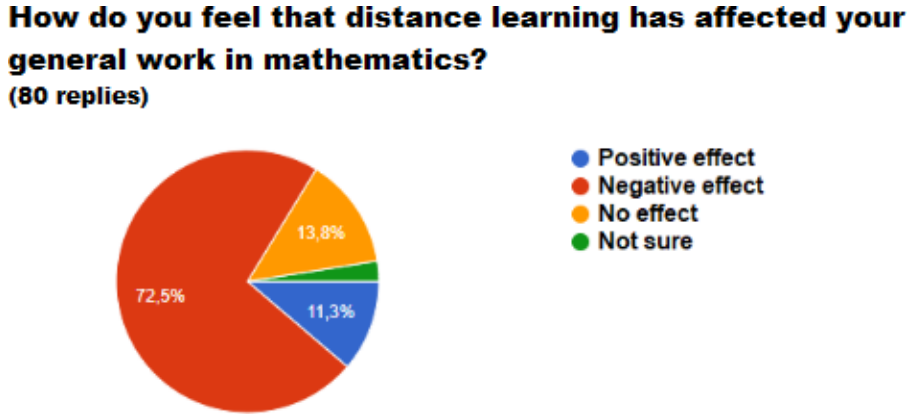

Figure 5: Distance teaching's effect on student's general work in Swedish upper secondary school mathematics

The quantitative data show that when asked in the survey about how distance teaching affected the students general work, out of 80 respondents 58 (72.5%) answered that it had a negative effect, 9 (11.3%) answered that it had a positive effect, 11 (13.8%) answered that it had no effect and 2 (2.5%) answered that they do not know. This indicates that while some students worked better at a distance, a strong majority of students' general work was negatively affected by experiencing mathematics teaching online. This can be linked to studies stating that an increase in student responsibility regarding their learning can lead to reduced learning in mathematics (Engelbrecht & Harding 2009; Loch, 2008; Dalland & Kettle, 2016).

Qualitative data from the open-answer question on the survey show that students that previously answered that they had a positive effect gave reasons such as that it was easier to plan their work and they did not get distracted as easily at home. Students that answered that their general work was negatively affected gave reasons such as that they rarely did anything during lectures, were easily distracted, it was boring working alone at home, and had difficulty concentrating and staying motivated. These reasons also align with the theories that higher disciplined and more motivated students can benefit from distance teaching while less motivated students suffer (Engelbrecht & Harding, 2009; Loch, 2008; Dalland & Kettle, 2016).

In the interviews, all three students that prefer traditional teaching said that their general work was negatively affected by distance teaching as it was easier to procrastinate and get distracted. Meanwhile, all three students that prefer distance teaching said that their general work was positively affected by distance teaching or not at all since they felt more freedom and flexibility in their studying and did not need a teacher to decide when and what to study. This is in line with what Dalland and Kettle (2014) showed in their study regarding how students in a classroom tend to either finish their work quickly or procrastinate as much as possible. All three teachers indicated that the effect distance teaching had on students' general work in mathematics seemed to vary depending on the student but generally it was negative. One teacher summarized it:

> *"I think that the students who have their own driving force are not so dependent, they work in much the same way regardless of whether they are in a classroom or at a distance. But the students who have a greater need for help, their own work suffers from not having the same direct contact." - Interview teacher 3*

Both students and teachers' experiences agree with previous studies that state how distance teaching can be beneficial or detrimental to mathematics teaching and student learning depending on which student you look at (Engelbrecht & Harding, 2009; Loch, 2008; Dalland & Kettle, 2016). These results are also in line with the theories of inner and outer motivation and how some students need outer motivation in the form of teacher encouragement and feedback (Illeris, 2015; Deci & Ryan, 2000). Additionally, teacher 2 mentioned that every student's grades had decreased during distance teaching which means that the outcomes of distance teaching were not the same as the outcomes of traditional teaching. However, this may be due to how the distance teaching was conducted by the teacher and that the students did not have equivalent learning experiences as when they were in a physical classroom, which Simonson (1999) explains by the equivalence theory.

The qualitative and quantitative data show that while some students experienced a positive effect on their general work, most students experienced a negative effect on their general work following the transition to distance teaching. This indicates that since the majority of students work less frequently and less effectively during distance teaching, distance teaching can be said to be detrimental for the average student's learning. The qualitative data further indicate that several students who initially had goals and interests of achieving the best possible grade instead focus on achieving a passing grade during distance teaching as they found the course more difficult due to lack of teacher assistance and continuous feedback. This is in line with previous studies and theories stating that distance teaching in mathematics is difficult and can

have negative effects on student motivation and goals (Bryceson, 2007; Klapp, 2015; Illeris 2015).

5.3 Motivation

To better understand their preference, students were asked how distance teaching affected their motivation in upper secondary school mathematics. The results are depicted in the graph below.

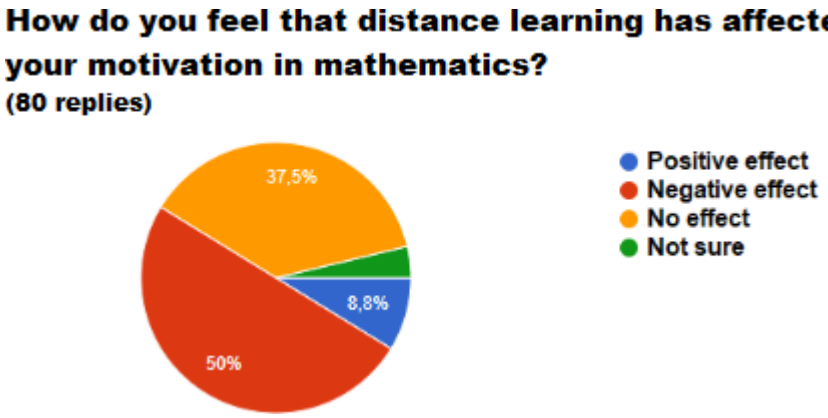

Figure 6: Distance teaching's effect on student's motivation in Swedish upper secondary school mathematics

The quantitative data show that when asked in the survey about how distance teaching affected students' motivation, out of 80 respondents 40 (50%) of the respondents answering that it had a negative effect on their motivation, 7 (8.8%) answered that it had a positive effect, 30 (37.5%) of the respondents answered that it had no effect and 3 (3.7%) answered that they do not know. These results show that the number of students whose motivation was negatively affected far outweigh the number of students whose motivation was positively affected. These results are in line with results from previous studies on distance teaching in Sweden (Åkerfeldt & Hermansson, 2020; Sveriges Elevkårer, 2020).

From the qualitative section of the survey's, students have given some explanation. The students that answered that distance teaching had a positive effect on their motivation gave reasons such as that they have more time on their hands and could get more done at home. For example, one of the students wrote:

> *"I had the choice to study the way and the time that suited me best which made it more fun and easier. During regular lessons, it can otherwise happen that you just sit and waste time because you do not have the energy or do not have motivation, but at a distance I could, for example, do English during a math lesson and math during English if it suited me better." - Survey student 9*

The students that said previously answered that distance teaching had a negative effect on their motivation gave reasons such as it was difficult finding motivation to actively study in their home environment, the lack of structure and routine in their day, that the subject seemed more

difficult and the absence of a *present teacher*. This was emphasized by a student who indicated:

> *"My grades quickly went down during the distance because I could not take part in the teaching in the same way and it felt more difficult to ask for help if you needed it when everyone could hear." - Survey student 43*

The students that previously answered that distance teaching had no effect on their motivation mostly gave no reason, but some said that since they had a predetermined goal in mind, the change in environment did not affect them. These results indicate a negative correlation between distance teaching's effect on student motivation and what was earlier described as student's inner and outer motivation (Illeris, 2015; Deci & Ryan, 2000). The results further strengthen the indication that distance teaching does not necessarily affect students who have higher inner motivation but negatively affect students who have low inner motivation (Illeris, 2015; Deci & Ryan, 2000). The fear and reluctance of asking questions in front of the whole class as indicated by Oyedeji (2017) who described it as detrimental for student motivation, participation and learning was emphasized in the above results.

From the analysis of the interviews, three of the students preferred traditional teaching and three preferred distance teaching. The students that preferred traditional teaching mentioned that distance teaching had negative effects on their motivation because of the change in structure and routine, focus problems and it was not as fun or serious. For example, students 1 and 4 stated:

> "*Because it does not feel like a real lesson, you lose motivation. I could sort of go and make a sandwich or watch Netflix during class*." *- Interview student 1.*

> *"I lost some focus and I felt much worse at math and I did not think it was as fun anymore. It almost made me not choose math 5, but I still chose it in the end." - Interview student 4*

Meanwhile, the students that preferred distance teaching answered that their motivation is independent of the environment and instead dependent on predetermined factors such as doing well on tests and achieving a specific grade. Student 2 emphasized this by saying:

> *"For me, my motivation is that I want to write well on exams, so it does not matter if I am in the classroom or at home. So no impact." - Interview student 2*

These interviews further support theories of inner and outer motivation as well as that motivation can be seen as a requirement to complete tasks and achieve results. Some of the survey students showed an interest in doing well, studying, and achieving certain results but needed some outer motivation and guidance to achieve these results which was absent during the distance teaching. This absence of outer motivation led to students perceiving the subject as more difficult due to not being able to complete certain tasks and achieve certain results. This led to a further decrease in motivation which is in line with how Klapp (2015) and Deci and Ryan (2000) describe that outer motivation in the form of negative outcomes and feedback can lead to a reduced inner motivation.

Similarly, to the interviewed students, the interviewed teachers also ascribed that it depends on which students you look at, some students had their motivation unchanged while some had it negatively affected. However, all of them agreed that most students experienced a negative effect and none of the three teachers mentioned the possibility of a student's motivation increasing. Teacher 3 stated:

> *"For the vast majority, I think the motivation has diminished. A smaller group has maintained the same motivation and a larger group has lost it." - Interviewed teacher 3*.

Teacher 2 however, described the lack of teacher assistance by saying:

> *"You motivate students by giving feedback, talking to them, being social and creating a relationship with them. If you create a relationship with the students and they start to like you as a teacher, they also want to show that they know math and they do not want to disappoint you either. But when there is distance, you do not create the same relationship with the students, which reduces their motivation." - Interviewed teacher 2*

These results strengthen the theories of inner and outer motivation as well as the theories and studies describing the teacher's role in students motivation. The absence of the student teacher relationship that arose in distance teaching can lead to several negative consequences. The absence of teacher-student relationship and the difficulty of assessing how a student is learning makes it increasingly difficult for a teacher to find a student's ZPD (Vygotsky, 2005) according to Bryceson (2007). Furthermore, the absence of communication makes continuous and formative feedback (Klapp, 2015) practically impossible. The only outer motivation that becomes available for students are grades and test results which can have negative consequences due to test results being negatively affected because of the increasing difficulty of distance mathematics.

5.4 Receiving help from teacher

To better understand their preference, students were asked how distance teaching affected their ability to receive help from their teacher in upper secondary school mathematics. The results are depicted in the graph below.

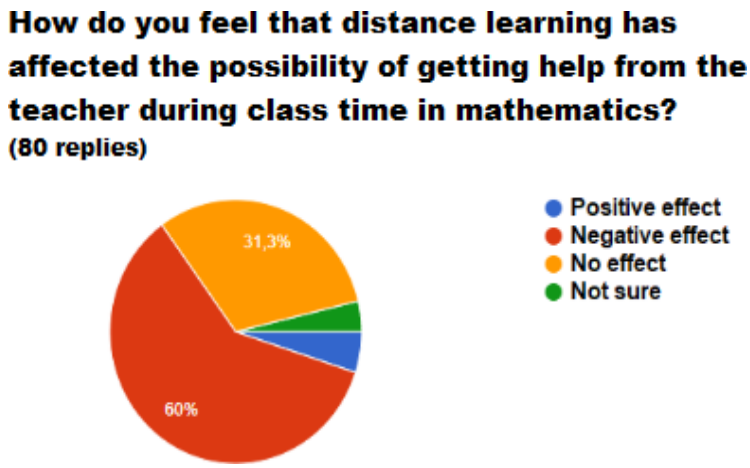

Figure 7: Distance teaching's effect on student's ability to receive help from teachers in Swedish upper secondary school mathematics

The quantitative data show that when asked in the survey about how distance teaching affected the student's ability to receive help from the teacher, out of 80 respondents 48 (60%) answered that distance had a negative effect on it, 4 (5%) answered that it had a positive effect, 25 (31,3%) answered that they do not have a preference and 3 (3.7%) answered that they do not know. The significant number of students that answered no effect may be due to them individually not being as dependent on help as others, or as Dalland and Kettle (2016) would define them, self-regulating.

The qualitative data from the surveys gives some but limited explanations to the statistics. The students that answered no effect felt like they did not need to ask the teacher anything, which can be a source of error in the statistics as this means they never investigated the possibilities of receiving help during distance teaching, in the analysis of Bjørndal (2005) this would be the source of error *answering options that are not covering enough*. The students that answered negative effects stated that it was harder to ask and receive help during distance teaching which goes in line with what Hamann et al. (2012) found in their study. Some of the reasons from the survey were that communication was harder and the fact that you couldn't show your notebook in the same way as in a physical classroom to express the problem. This goes to show a limitation in utilizing the necessary artifacts (Wartofsky, 2012), both primary (the notebook) and secondary (language) as Vygotsky (2005) was keen to express.

From the interview part of the qualitative study all 6 students pointed out that the possibility of receiving help from a teacher was negatively affected, even the students that preferred distance teaching in general. One of the students that preferred distance teaching said this:

> *"It was probably much worse. I rarely asked for help and I could use the internet a lot but I now noticed afterwards that many more questions were asked in a physical classroom than distance. I think people were afraid to ask questions in front of the whole class. I was not afraid like that but I rather use google more often than asking questions to the teacher." - Interview student 5*

The 3 teachers that were interviewed testified to the same conclusion. One reason given by teacher 3 is that it is harder for a teacher to see and notice the students digitally than physically. So when students ask for help they might not get a response as fast. Other reasons noted, from both students and teachers, were that it takes more courage and includes more social risks to ask for help and it is harder to communicate the help that you need with practically only words. This may be due to students not wanting to look dumb in front of their classmates, which is in alignment with what Bennet (2010) and Canfield & Wells' (1976) described with the poker chip theory. One quote from a teacher:

> *"In part, I think it may be because it is harder to break the screen barrier, so to speak. So that you go in and really press the "raise hand" button and have to say something on the computer, I think it feels like you have to have something important to say and have a question that is really relevant. This spontaneous "Teacher! Come and look at this" does not really occur at a distance." - Interview teacher 1.*

5.5 Classroom communication

To better understand their preference, students were asked how distance teaching affected the classroom communication in upper secondary school mathematics. The results are depicted in the graph below.

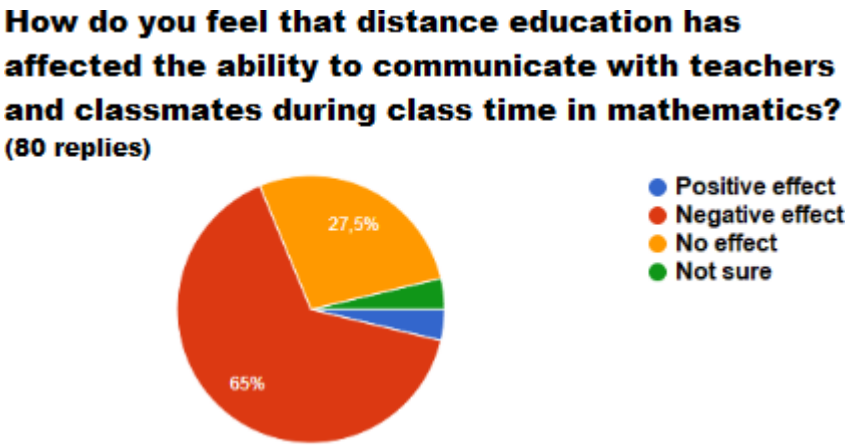

Figure 8: Distance teaching's effect on classroom communication in Swedish upper secondary school mathematics

The quantitative data show that when asked in the survey about how distance teaching affected the classroom communication, out of 80 respondents 52 (65%) answered that distance teaching had a negative effect on classroom communication, 3 (3.8%) answered that it had a positive effect, 22 (27.5%) answered that it had no effect, and 3 (3.7%) answered that they do not know. This is in line with previous studies showing that classroom communication was lacking during distance teaching (Smith et al, 2002; Sveriges Elevkårer, 2020; Åkerfeldt & Hermansson, 2020).

Qualitative data from the open answer questions on the survey show that out of the students who prefer traditional teaching only two experienced a positive effect on classroom communication. Survey student 42 wrote:

> *"For me, it was quite easy to communicate with classmates in the form of other websites where you could share notes and get help from each other. However, it was more difficult to get in touch with the teacher." - Survey student 42*.

This is in line with previous studies showing that some students find a way to communicate with each other even if the teacher did not actively promote cooperation (Sohl, 2020).

Every student who previously indicated that they prefer distance teaching answered that they experienced a negative effect on classroom communication, and this was elaborated by survey student 4:

> *"It is much harder. I am pretty shy and nervous and did not want to ask questions in front of the whole class. It is not so convenient to write to the teacher in the classroom chat if you have any questions." - Survey student 4*

> *"Difficult to discuss with the teacher and other students, only one person can say something at a time during distance." - Survey student 35*

Qualitative data from the interview show that all six students stated that classroom communication was practically non-existent between two or more students and students and teachers. All three teachers had similar experiences and said that classroom communication was dramatically reduced during distance teaching. However, all three teachers stated that with the implementation of group rooms/breakout rooms communication seemed to have improved both between students and between student and teacher. This ultimately affects the student's learning and cognitive development since interactive mediation is limited, according to Vygotsky (2005). Here follows two quotes from the interviews:

> "*There were no dialogues at all. Sometimes I talked and no one answered at all. The teacher used to say that it feels like he is talking to the computer when no one is answering." - Interviewed student 1*

> "*Zero communication in math lessons in the beginning. Then came breakout rooms where you could have given out a group assignment that forced them to collaborate a bit." - Interviewed teacher 2*

The results show that the majority experienced a negative effect on classroom communication during distance teaching. Very few experienced a positive effect, however almost a third experienced no effect, this could be classrooms where students had become closer to each other and to the teacher prior to the transition to distance which facilitated classroom discussions and communication during distance. Another possibility is that these students could have used a tool which enabled group rooms during the entirety of their distance teaching, something which all 9 interviewed persons said was unavailable at first. Every interviewed person said that classroom communication increased with the implementation of group-room availability which implies the necessity for a tool that allows and facilitates classroom discussion in groups. This goes in line with what Bryceson (2007) said regarding

the necessity of a tool that allows and facilitates group discussions to increase student learning by allowing them to engage in their learning, which is further advocated by Skott et al. (2010) as he emphasizes the importance of communication in teaching and learning.

5.6 Classroom participation

To better understand their preference, students were asked how distance teaching affected their classroom participation in upper secondary school mathematics. The results are depicted in the graph below.

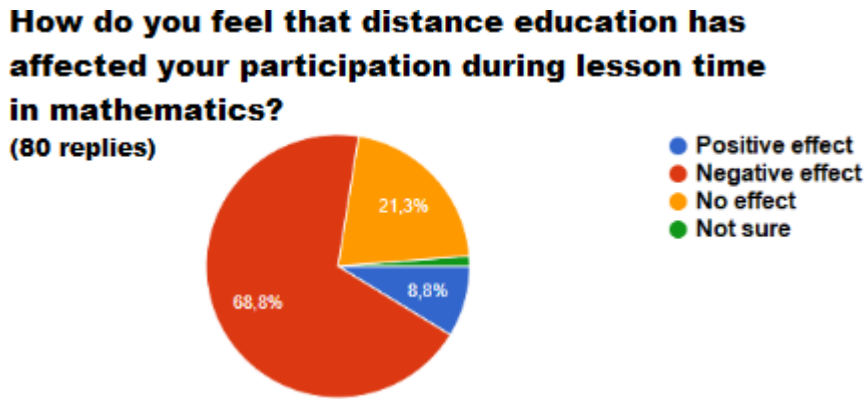

Figure 9: Distance teaching's effect on student's classroom participation in Swedish upper secondary school mathematics

The quantitative data show that when asked in the survey about how distance teaching affected the student's classroom participation out of 80 respondents 55 (68.8%) answered that distance teaching had a negative effect on student's participation, 7 (8.8%) answered that it had a positive effect, 17 (21.3%) of the students answered that it had no effect and 1 (1.2%) answered that they did not know.

Qualitative data from the open answer questions on the survey show that students who prefer traditional teaching almost entirely experienced a negative effect on classroom participation and only two experienced a positive effect on it. None of the students that prefer distance teaching answered that they experienced a positive effect on classroom communication.

Qualitative data from the interview show that all six students experienced a decrease in classroom participation. Interview student 2 and 5 said:

> *"The teachers could not keep track of what the students were actually doing. They assumed that the students were listening but students sometimes came, took attendance and went away. It was not like normal where teachers see who is there and actually working." - Interviewed student 2*

> *"There was never anyone who answered the teacher's questions or asked any follow-up questions so the teacher started asking students less questions and if they understood. I think it has to do with what I said before, that it is kind of 'uncool' to answer. Uncool, maybe is not the right word, I do not think anyone*

really thought or cared about being cool but it kind of did not feel right or good to talk, ask questions and answer a lot." - Interview student 5

These results are in line with the findings of studies regarding online teaching which showed that students less frequently engage in discussions during distance teaching (Smith et al., 2002; Safavi et al., 2013; Hamann et al., 2012). The quote from interview student 5 can be linked to Bennett's (2010) poker chip theory and Wernersson (2010) and Zimmerman's (2019) theories about anti-study-culture. This reduction in classroom participation would, according to Skott et al. (2010), have a negative effect on students' learning as Skott et al. views learning as participation as crucial for students.

All three teachers stated that they experienced decreased classroom participation during distance teaching even though attendance was generally higher than before. The main reason for this was that it was not mandatory for students to have their camera and microphone on which enabled students to have total freedom over what they would do during lectures and often did not listen. Teacher 1 said:

"If you see participation as how active you are in the class, then there is a negative correlation in that case, and then you have to take into account that it is more difficult to determine at a distance who is active and who is not. And you can see that in yourself a bit too, if I have a job meeting at a distance where I do not have to turn on the camera and microphone, I can have the sound on loud and do the dishes or something while not really focusing 100%. Attendance increased while participation deteriorated. And that is because it was easier to attend, but you do not really need to participate and keep up and 'be there' compared to when teaching is physical." - Interviewed teacher 1

This difficulty described by interviewed teacher 1 goes in line with the camera and microphone problem described in the study by Molin et al. (2020). It is not an easy problem as teachers cannot force students to turn their camera or microphone on as some students absolutely do not wish to show their home environments. The quantitative and qualitative data both indicate a strong decrease in classroom participation and the qualitative data show that a major factor in this decrease is the freedom students have had of turning off their camera and microphone for the duration of the lecture.

6. Results and analysis - Development

This section aims at providing findings relevant for the second research question of this study (See section 1.1.1) which covers designing a handbook that facilitates distance teaching for students and teachers. To achieve this, this section will include analyses of some of the data that have already been presented in Section 5 as well as data that will be presented here for the first time. The analysis will aim at identifying major and minor difficulties and challenges that teachers and students experienced, then presenting potential solutions that will be further discussed in Section 7.3. The section will follow the structure of presenting different identified major and minor challenges in respective subsections that include a description of the challenge, how they relate to the experienced difficulties and finally, a subsection which includes potential solutions for the challenges. The distinction between which challenges are perceived as major or minor is made by considering how many students were affected by the challenge and how great the consequences of the challenge was said to have on students' learning experiences.

6.1 Major challenges

The first major challenge that the findings showed was the *reduced student work* that followed distance teaching. Student work could not be monitored by the teacher as students could have their camera and microphone turned off. This gave students more freedom in what they could do during lectures and made students more susceptible to things like distractions and procrastination. This led to a negative effect on student work and learning, which is a risk that earlier theories and studies have stated (Engelbrecht & Harding 2009; Loch, 2008; Dalland & Kettle, 2016).

The second major challenge is intertwined with the first one and it is the *reduced teacher presence*. As most students had their camera turned off, rarely spoke and/or asked questions, the teacher's role diminished. Students that did not work during lectures due to for example distractions and procrastination, would work after school-hours, where the teacher is not available to help. This means that some students mainly studied asynchronously which could have had negative effects on their learning as they miss on possibilities to discuss and feel as part of a community which are beneficial for their learning (Hrastinski, 2008; Safavi et al., 2013). A survey student stated:

> *It has been difficult to motivate oneself to actively participate. It has been possible to take it easy during class time and then study in the evening. - Survey student 54*

This led to an increased student responsibility of their own studies and learning which could be too heavy for some students and further reduce their work and effort (Dalland & Kettle, 2016; Klapp, 2015). Furthermore, this led to a shift in the teacher's role, where the teacher's role went from being a leader who encourages, guides, and facilitates students' learning, to resembling that of a lecturer at a university that only introduces theories. The problem with this is that communication between student and teacher is vital for students' learning leading to reduced learning and reduced opportunities for developing mathematical competencies (Vygotsky, 2005; Skott et al., 2010; Malten, 1998).

The third major challenge concerns *reduced social aspects* in the classroom. Findings showed that with one big virtual classroom came reduced classroom communication and participation as well as higher social awareness for students, especially for students that did not know their classmates very well. Students rarely communicated with each other as this would disturb the whole classroom and virtually raising their hand to ask questions rarely happened due to it seeming more serious as well as the fear of having to ask questions in front of their classmates. The problem with this is that student discussions suffer which can lead to students reflecting less and not having the possibility of developing the intended mathematical competencies such as communication and thinking competencies (Skott et al, 2010).

The fourth major challenge is regarding *some teachers lacking digital competence*. Findings revealed that some teachers could experience technological difficulties when trying to hold distant lectures. According to interviewed teacher 2, teachers at the same school, especially of older age, had major problems navigating through and using digital platforms when trying to hold lectures. Interviewed teacher 2 said:

> *It felt like for us young teachers who work with computers, mobiles and stuff, it was no problem. But the older teachers who are 50-60 years old, had huge problems, so I had to help many via for example facetime. And the school did not do much. We had one day off to prepare and would go over to distance the next day, but nothing happened that day. There was a lot of talk, but little action. - interview teacher 2*

These findings indicate that schools did not provide teachers with a sufficient introduction to the intended digital tools and platform nor enough time for teachers to familiarize themselves with the digital tools and platform on their own. This led to consequences such as detrimented e-Teaching which in turn leads to reduced e-Advising (Tchoshanov, 2013) and losing time from the intended lecture, if not the whole lecture as interview student 1 describes:

> *During the distance there were many teachers who were not technical at all. It happened once that a teacher had turned off the sound on his microphone and talked the whole lesson while everyone wrote in the chat that we did not hear her. But she never saw the chat and continued. So that was a whole class wasted. So what teachers need is a technical introduction. - interview student 1*

6.2 Minor challenges

The first minor challenge was revealed in the findings as students also experienced some technological difficulties or limitations when trying to communicate their work. Findings showed that students had a harder time explaining their work as there was a digital barrier limiting them from showing their notebooks without it being blurry or inverted. This meant they had to communicate everything with just words which proved to be increasingly difficult for the students as it was not a sufficient mediation tool (Vygotsky, 2005). This leads to reduced opportunity for students to properly communicate what they need help with and a reduced opportunity to develop communication and reasoning competencies (Skott et al., 2010).
Furthermore, the second minor challenge was a technical limitation regarding teachers' poor video and audio quality. Student answers on the survey noted this, saying:

> *Schools should provide better digital tools for both teachers and students, especially sound but also images if the teacher shows something. - Survey student 2*

> *It is easier to follow traditional lectures, and presentations are easier because many times during distance, you could not see the board due to poor technology or camera quality. - Survey student 70*

By not hearing or seeing the teacher and the presentation the e-Advising in the classroom is detrimented which in turn had a negative effect on the students' will to learn, their motivation, their interest and attentiveness (Tchoshanov, 2013). Students may feel that the teacher is absent and resort to the thought of learning everything by themselves, which is counterproductive to learning (Vygotsky, 2005; Illeris, 2015; Skott et al., 2010; Simonson, 1999).

The third minor challenge is regarding how qualitative data showed that some students experienced that their teachers handed out too many assignments that the students had to turn in at the end of the lecture as a way for the teacher to ensure students were working. Findings revealed that this further demotivated students as they experienced deteriorated teaching accompanied by an increased workload which is in accordance with Klapp's (2015) description of how increased difficulty can lead to a reduced motivation.

The fourth minor challenge was regarding the students' structure. Findings revealed that students experienced a lack of structure in their day as the aspect of getting ready for school disappeared. Interviewed students stated:

> *It was very difficult to suddenly get used to waking up and immediately enter study-mode. - Interviewed student 3*

> *When I was at a distance, it could often happen that I slept during lectures, especially if it was in the morning. - Interview student 1*

This reveals a challenge that students encountered regarding the change in environment. As students no longer had to travel to school but instead just click on a button to *connect to school*, they did not need to prepare for school anymore and would wake up right before the lecture started. The problem with this is not only that being newly awakened can lead to reduced focus but also that students do not mentally prepare themselves for school which findings showed lead to a reduced seriousness of classroom environments which can in turn lead to decreased student focus and work.

The fifth and last minor challenge is regarding technological difficulties such as loss of internet connection during lectures. Findings showed that some students experienced problems with internet connection during lectures which resulted in them missing out on lectures and learning opportunities. As most testified to lectures not generally being recorded made it therefore hard for the students to recuperate the class time they unfortunately missed. This led to students having to take their learning into their own hands in distance learning and without a teacher which severely reduced their possibilities to learn (Vygotsky, 2005; Illeris, 2015; Skott et al., 2010; Simonson, 1999).

6.3 Potential solutions

A large factor in the first and second major challenge was that students had their cameras turned off during lectures. The issue of students being able to turn off their camera has been stated by a previous study (Molin et al., 2020) and while students can keep their microphone turned off, the downsides to allowing a student to turn their camera off are too severe. The downsides are, amongst many, for example that the teacher cannot see if the students are working or not, the teacher cannot read body language and decode meanings (Maltén, 1998; Mustafa et al., 2019) and the teacher will have difficulty in identifying which students need encouragement. By having students turn their camera on for the duration of the lecture, the teacher can better monitor students and assist them in several ways such as helping them regain focus when they get distracted and encouraging them to work and ask questions. This would also revitalize the teacher's presence and role in the classroom which in turn leads to a reduction of student responsibility as they would then encounter more encouragement, guidance and other factors increasing their outer motivation (Illeris, 2015). Furthermore, working with mathematics will most of the time require students to use pen and paper which means that teachers would no longer have to hand out assignments to see which students were working or not as they would directly see which students are working or not. This would also reduce the risk of students not taking lecture time seriously and can no longer lay in bed or not work at all. This first potential solution would therefore have a direct effect on prevention of the first major, second major, third minor and fourth minor challenges,

A second potential solution is needed to prevent social challenges, such as the second and third major challenges. These arose because of the entire classroom sharing one big virtual room which made it so that everyone would hear everything that is said whether it was students asking the teachers a question or students trying to converse or discuss with each other. Therefore, a potential solution to prevent similar social challenges is to ensure that distance lectures are held through a digital tool that allows for the creation and use of group rooms. This allows for students to be separated from the rest of the classroom if they want to ask a question in private. Furthermore, Bennett (2010) stated that students would be more willing to discuss and communicate during smaller groups which strengthens the idea of virtually replicating desk-environments by assigning two or three students to a respective virtual group room where they can communicate with each other. These smaller groups will also increase teacher presence as the students are discussing and working during class time and the teacher can enter the smaller groups to listen, encourage and guide the students in their thought processes, promoting learning through the theories of ZPD by Vygotsky (2005). This potential solution therefore has a direct effect on the preventions of the second and third major challenges but also has an indirect effect on the first major challenge. As students now are separated from the rest of the class, they can communicate more with their group-partners and the teachers when the teachers visit their group which promotes their work.

A third potential solution is intertwined with the second and regards group-assignments. In these smaller group rooms, the students can still be reluctant to study due to for example the anti-study culture (Zimmerman, 2019; Wernersson, 2010). The teacher could therefore provide group assignments at the end of every or every other week prompting the students to discuss with each other, which is crucial for learning and provides increased opportunity to develop more intended mathematical competencies (Skolverket, n.d.c; Skott, 2010). As the students now regain a *work-space* similar to that of a desk in their traditional teaching

accompanied with one or two classmates to discuss regular work and group assignments with, their general work could experience a positive effect. If done together with the first potential solutions which eliminated the need for too many submissions, reoccurring group submissions could reverse the negative view on submissions. If the teacher rewards students doing well on these group assignments by for example giving out extra points on a grading moment, students view on these assignments can become positive as they now view it as a reward for their effort, which is good outer motivation (Shabani et al., 2010; Ayub, 2010; Lei, 2010; Klapp, 2015). By creating an environment where communication and discussions are encouraged and vital, the students' work and effort are increased. This potential solution would therefore further the direct effect on the prevention of the second major, third major and third minor challenge but also have an indirect effect on the fourth minor challenge as the students now will take the lecture more seriously due to the submissions.

A fourth potential solution would be for schools to provide teachers with tools that are necessary and facilitate distance teaching as well as a thorough introduction in how to use these tools. This solution is in accordance with the findings of Hrastinski et al. (2010) which noted the importance for teachers to properly learn how to use digital tools and media. The schools would need to evaluate different digital tools and ensure that they include functions that facilitate distance teaching such as for example screen sharing and a virtual whiteboard that students and teachers can use to show their work. This can also cause the students to be more interested in learning as using digital tools for exercises can infuse interest according to Nyström & Trygg (2020). By providing teachers with such tools and a thorough introduction in how to use these tools, this would help with the prevention of several technological difficulties and limitations described by students. Therefore, this potential solution would have a direct effect on the prevention of the fourth major, first minor and second minor challenge but also an indirect effect on the first, second and third major challenge as communication in the classroom would be facilitated which in turn helps and promotes student work. This way schools can strive to achieve an equality of learning and teaching circumstances during distance teaching (Simonson, 1999).

A fifth potential solution would be for teachers to provide a thorough study-guide for students to follow that includes what each respective lecture will include and potentially a referral to a video that would cover theory that the lecture was intended to introduce. The study guide could be a form of schedule that shows the date and time of each lecture with a description of the intended content of the lecture. The videos could be for example a recording of the theory-introduction conducted during the lecture that is later uploaded by the teacher or a link to a video on a website such as YouTube that covers the same theory in a short video of between two and five minutes. Both forms of videos could be made available as the link to a short YouTube video could be something students look at before the lecture to potentially prepare themselves and the recording of the lecture introduction can be something students look back at after the lecture to recap or learn from if they missed the lecture. By making these materials available, the teacher promotes and facilitates students' e-Learning (Tchoshanov, 2013) as well as making it easier for students to catch up if they were to miss out on a lecture due to other priorities or emergencies forcing them to study asynchronously (Hrastinski, 2008). This solution would therefore directly help with the prevention of the fifth minor challenge but also indirectly help with the fourth minor challenge, as these short YouTube videos would be something students could use to mentally prepare them for a lecture and look at before a lecture starts due to their short nature.

The following table represents how the different solutions (S1-S6) affect prevention of different major (M1-M4) and minor (m1-m5) challenges by: *DE (green)*, which stands for direct effect, *IE (yellow)*, which stands for indirect effect and *NE (orange)* which stands for no effect.

Table 4: The effects different solutions have on different major and minor challenges.

Solutions → **———————** **Major challenges ↓**	**S1: Have students turn their cameras on**	**S2: Utilizing virtual group rooms**	**S3: Regular group assignments once every or every other week**	**S4: Provide teachers with digital tools and an introduction to these**	**S5: Provide students with an extensive study guide and digital material**
M1: Reduced student work	*DE*	*IE*	*DE*	*IE*	*NE*
M2: Reduced teacher presence	*DE*	*DE*	*DE*	*IE*	*NE*
M3: Reduced social aspects	*NE*	*DE*	*DE*	*IE*	*NE*
M4: Some teachers lacking digital competence	*NE*	*NE*	*NE*	*DE*	*NE*
Minor challenges ↓					
m1: Technological difficulties communicating work	*NE*	*NE*	*NE*	*DE*	*NE*
m2: Teachers' poor video and audio quality	*NE*	*NE*	*NE*	*DE*	*NE*
m3: Too many assignments	*DE*	*NE*	*DE*	*NE*	*NE*
m4: Reduced student structure	*DE*	*NE*	*IE*	*NE*	*IE*
m5: Internet difficulties during lecture time	*NE*	*NE*	*NE*	*NE*	*DE*

6.4 Creating, testing, and improving the handbook.

The purpose of the handbook is to help schools and teachers facilitate and integrate distance teaching into upper secondary school mathematics, therefore it was deemed that the

handbook would contain the three following sections: Background, Challenges and difficulties, Advice and References.

The background section would include a brief introduction to the handbook and its contents as well as the purpose of the handbook and how and why it was made. The challenges and difficulties section would give an overview of the challenges that this study found, and the advice section would summarize the potential solutions for these challenges in a list of advice to the schools and teachers separately. The advice written in the handbook was created with regards to the challenges, solutions, Wahlströms (2016) five didactical questions, Skolverket's mathematical competencies (n.d.c) and the fourth SDG (Svenska FN-förbundet, 2020).

The first version of the handbook was a prototype meant to be tested and improved. SVID (n.d.c) and Hrastinski et al. (2010) emphasize on the importance of refining and improving proposed solutions through tests and evaluations. In this study, the handbook was tested by sending the first prototype to the previously interviewed teachers and receiving feedback. The collected feedback was summarized and used to fill out a testing and evaluating template including what was good, what was not so good and potential improvement points (See Appendix 3). The main improvement points from the feedback were to include further advice both to school and to teachers.

Regarding advice to schools, the feedback indicated that teachers could face ethical dilemmas in forcing students to turn their camera on as this could show their homes. Therefore, advice to schools now included advice regarding the utilization of digital tools that allow students to have a virtual background to ensure that no students feel that their privacy is invaded.

Regarding advice to teachers, the feedback indicated that the advice that was written was good and would have helped the teachers at the start of the pandemic. However, they wished to see more general advice that were not necessarily rooted in the major and minor challenges that the findings presented. Examples of such advice were: Teachers making sure their internet, cameras and microphones are working before the start of a lecture and that teachers should display a positive attitude towards teaching and mathematics as the students will reflect this.

7. Discussion

This section includes discussions regarding how the results and analysis of said results relate to the research questions and previous theories and studies (See section 2). The study consists of a research and development part. The first research question regards the research part of the study, and the second research question regards the development part of the study. The research questions are:

1. What are upper secondary school teachers' and students' experiences of distance teaching of mathematics during the pandemic?

2. How can a prototype of a support material, in the form of a handbook, be designed for facilitation of integration and use of distance teaching in upper secondary school mathematics?

This section is divided into five subsections and the first subsection 7.1 presents the findings from section 5 and 6 are summarized, followed by subsection 7.2 where the findings from section 5 will be discussed from a sociocultural perspective and how the findings relate to other previous theories and studies (See section 2). Subsection 7.3 includes a discussion regarding the findings from section 6 and how the findings relate to other previous theories and studies (See section 2). Subsection 7.4 includes limitations of this study which is followed by subsection 7.5 which includes suggestions for further studies and research.

7.1 Summary of findings

In the result and analysis section, data was presented and analyzed by first presenting and analyzing which form of teaching that students and teachers preferred and why. Afterwards, the effect that distance teaching had on five different aspects of mathematics teaching was studied and analyzed (See section 5).

The first aspect was students' general work and how distance teaching affected it. The quantitative data showed that a small portion of students answering that distance teaching had no effect or that distance teaching had a positive effect on their general work. However, most students experienced that distance teaching had a negative effect on their general work. The qualitative data were in line with the indication that the average student's general work was negatively affected. This was stated by all three interviewed teachers and the three interviewed students who preferred distance teaching also said that they noted that many of their classmates and friends experienced a negative effect.

The second aspect was student motivation and how it was affected by distance teaching. Quantitative data showed that exactly half of the students answered that distance teaching had a negative effect on their motivation, more than a third of respondents answered that distance teaching did not affect their motivation and only a small amount answered that distance teaching had a positive effect on their motivation. The qualitative findings show that the described advantages could be categorized as timesaving and the increase in motivation was regarding motivation to work during lectures so that they would avoid "homework", in this

case meaning work after school-hours. The described advantages did not mention an increased learning, interest in mathematics or possibility for higher performance, whereas the disadvantages were numerous and described as detrimental for student learning, motivation to work and high goals. These findings imply that the few students who had high motivation and discipline prior to experiencing distance teaching did not experience a significant effect on their motivation while most of students' motivation was negatively affected.

The third aspect was the possibility of receiving help from a teacher during distance teaching. Quantitative data showed that more than half answered that distance teaching had a negative effect, a little less than a third did not experience an effect and only a small amount answered that it had a positive effect. The qualitative data were in line with the quantitative data's implication that teacher help was reduced during distance teaching. The qualitative data show that communication was generally lower and even though the possibility of raising your hand virtually existed, it seemed more serious, and students were reluctant to use this function due to the seeming seriousness of it and fear of asking questions in front of the whole class. The qualitative data also show that many classes did not have access to virtual group rooms where students could ask teachers questions during the earlier half of their distance studies. When virtual group rooms were implemented, an increase in student questions followed.

The fourth aspect was classroom communication and how it was affected by distance teaching. Quantitative data show that almost two thirds of respondents experienced that distance teaching negatively affected classroom communication, a little more than a fourth of students experienced no effect and a small amount experienced a positive effect. The quantitative data indicates that the classroom communication was generally worsened during distance teaching which the qualitative data was in alignment with. The qualitative data from open answer questions and interviews show that there was practically no communication between students and between student and teacher during lectures. Similarly to receiving help from the teacher, this could be correlated to the availability of virtual group rooms. The students who started distance teaching with virtual group rooms available would have likely seen a smaller or no effect at all on classroom communication while most students who did not have virtual group rooms available experienced a negative effect.

The fifth and last aspect was classroom participation and how it was affected by distance teaching. Quantitative data showed that more than two thirds of the respondents answered that their classroom participation was negatively affected by distance teaching, approximately a fifth experienced no effect and a small amount experienced a positive effect. The qualitative data is in line with this as the students who prefer distance teaching were generally students who did not participate much prior to distance teaching either and therefore mostly experienced no personal effect. However, almost every interviewed student and every teacher noted that classroom participation had been reduced. According to the qualitative data, this was due to how easy it was to do something else as it was more difficult to stay disciplined when there were more distractions at home and the students could turn off their camera and microphone so the teacher would not have any way of knowing if they were studying or doing something else.

Regarding which form of teaching is preferred, the quantitative data show that while a small portion of students answered that they have no preference or that they prefer distance teaching, a strong majority of students preferred traditional teaching. The qualitative data show

that the three interviewed teachers all preferred distance teaching and agreed with the downsides of distance teaching that the students described in interviews and open answer questions on the survey. The findings implied that while there are some students who experienced advantages of distance teaching, the disadvantages that most students experienced far outweigh them.

7.2 Discussing student's and teachers' experiences

This subsection will cover discussions regarding the research part of the study. More specifically, the discussion will regard how previous literature, theories and studies presented in Section 2 relate to the findings in Section 5. These discussions are made from a sociocultural standpoint and aim at better understanding and answering research question one (See section 1).

7.2.1 General work

The findings regarding student's general work indicate that distance teaching is detrimental to the average student's learning. The negative experiences described are in line with Dalland and Kettle's (2016) study which showed that the increase in responsibility that comes with self-regulated work can lead to reduced learning for students. Students stated that it was difficult staying disciplined enough to view the virtual lecture as a *real* lecture as all they did was press on a link to connect to the virtual room. This indicates that many students worked less during lectures. This decrease in work during lectures can be a factor in student's viewing the subject as increasingly difficult as they then have more to do after school hours which they then will do on their own with no teacher to explain and help them if they encounter difficulties. These students that study more on their own but need teacher assistance to progress will not achieve their zone of proximal development and therefore cannot make significant enough development to be able to do more work on their own (Vygotsky, 2005).

Klapp (2015) discusses how perceiving difficulty can in turn have negative consequences as the subject will feel less fun and students will feel less motivated to study that subject. This is something that was also seen in the findings as several students who initially had goals and interests of achieving the highest possible grade instead focus on achieving a passing grade during distance teaching. These findings are in line with previous studies showing that studying mathematics at a distance is difficult (Smith & Ferguson, 2005; Heppen et al., 2017). These students stated that they found the course more difficult due to lack of teacher assistance and continuous feedback. Lack of formative and continuous feedback (Klapp, 2015) can lead to a decrease in student motivation as the only feedback the students receive are graded tests which will probably have been negatively affected due to less work and increased difficulty. As feedback is an important factor in students' outer motivation, this situation can be viewed as one where students receive less outer motivation which can lead to less inner motivation (Deci & Ryan, 2000; Klapp, 2015; Amabile, 1993) which in turn can lead to even less of an effort from students.

7.2.2 Motivation

Similarly to general work, the findings regarding motivation indicated not only that fewer students experienced advantages than students who experienced disadvantages, but also

that the advantages seemed to hold less significance than the disadvantages. The findings were in line with previous studies stating distance teaching can be beneficial for students who are motivated regardless of external factors while remaining students will experience distance teaching as detrimental (Mupinga, 2005; Loch, 2008; Engelbrecht & Harding, 2009; Dalland & Kettle, 2016). Using the differentiation between inner and outer motivation (Illeris, 2015; Deci & Ryan, 2000), students who experience advantages of distance teaching seem to be students who possess higher inner motivation and have less need for outer motivation while students who experience disadvantages to distance teaching seem to be student who depend on outer motivation to continuously work and complete tasks.

The motivation required to complete tasks can be viewed as a bar that has to be filled (See Figure 10). The primary resource to fill this bar is inner motivation and if the inner motivation is insufficient, the rest can be filled with outer motivation. In a learning environment, the point where outer motivation is needed for a student to complete a task can be viewed as the student's ZPD (Vygotsky, 2005). The problem with this lies in the findings regarding a reduced teacher-student relationship. Teachers could not build a proper social relationship with students and give them continuous feedback on their work which according to previous studies is what good outer motivation needs to come from (Ayub, 2010; Lei, 2010). Students also stated that they were less motivated to work as they were reluctant to ask for help when needed due to the entire classroom hearing the question, which is in accordance with Oyedeji (2017). Consequently, achieving the students' ZPD will be practically impossible for teachers in these situations (Bryceson, 2007). Another consequence of this is that students experience the subject as more difficult which will, according to Klapp (2015), lead to even lower motivation. The increasing difficulty combined with the reluctance to ask for help could have led to students' achieving lower grades and due to the absence of continuous feedback, this was likely their primary source of feedback. This negative feedback would be harmful for their inner motivation (Deci & Ryan, 2000; Klapp, 2015; Amabile, 1993) and is in accordance with findings that showed that some students originally aimed for higher grades but gradually lowered their goals.

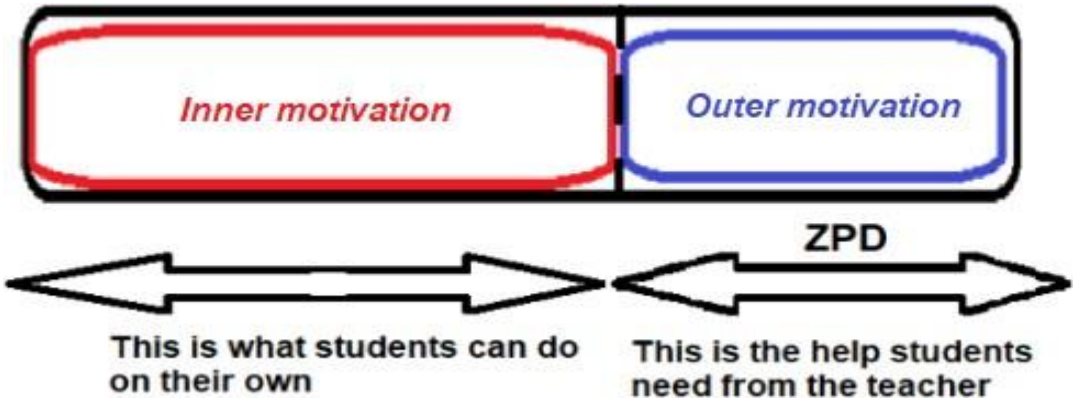

Figure 10: Conceptual framework

7.2.3 Student's receiving help from teacher

One of the biggest issues and most discussed aspects of distance teaching is the loss or the reduced occurrence of interaction which hurts learning tremendously. Vygotsky (2005) has described learning as a process that necessarily includes interaction between teacher and

student. However, as the quantitative and qualitative data noted, there are some self-regulating students that are not as dependent on interactions. This can be because they possess higher discipline and can therefore handle a higher sense of responsibility, as Engelbrecht and Harding (2009) stated. However, the vast majority are dependent on interaction, and they experienced difficulty asking and receiving help from their teacher. Even students that rarely ever asked for help acknowledged that it was an environment where asking for help seemed more serious and difficult. The teacher therefore had a harder time creating an environment which facilitates achieving the ZPD for a student which Vygotsky (2005) defines as a vital tool to go from the interpsychological part of learning to the intrapsychological part of learning.

One possible explanation for the reduced interaction is technology. Some of the qualitative data showed that it is harder for a teacher to notice and reach out to students that perhaps look confused while they are holding a digital lecture as it takes up their whole screen. This may result in the students not receiving equivalent learning experiences as in a physical classroom, consequenting theoretically in inequivalent learning outcomes as the equivalency theory states (Simonson, 1999). To further this already established hardship for teachers is the fact that most students had their camera turned off, so even when the teacher entered the room to check on the students, he/she was only met with black screens, which continues the loss of interaction and is a big problem according to Molin et al. (2020).

Another technological limitation is that at one point when the students wanted to ask the teacher something, they had to do so in front of the entire classroom as there were initially no virtual group rooms. This places the students at a socially vulnerable place as they have to ask questions which sometimes can be perceived as elementary in front of their whole class. This places weight on if it even is worth asking the question they had in mind, whereas in a traditional classroom the possibility of privately calling for the teacher existed. This social vulnerability is discussed in several studies and theories (Oyedeji, 2017; Bennet, 2010; Canfield & Wells, 1976) and is described as a risk to students' learning as they become less willing to participate and can even affect their motivation. As students encounter this social vulnerability more frequently in distance teaching due to the absence of student-teacher privacy, distance teaching can be viewed as detrimental for a student's learning.

A third technological limitation was the difficulty students encountered when conveying their work and what they needed help with. In a physical classroom the teacher could just look at students’ notebooks and form their conversation and the assistance to guide the student into see where they faulted. During distance teaching however, students could not show what they had done as they would have to hold their notebook up in front of their camera and hope that the image is clear enough to read. Instead, whenever a student needed help with a problem the teacher would work through the problem and show the student how to solve it. The consequence of this is that students miss out on deeper learning as the coding and decoding that Maltén (1998) describes does not occur. This makes it increasingly difficult for teachers to achieve the student’s ZPD (Vygotsky, 2005) and is what Bryceson (2007) described as a difficulty with distance teaching.

7.2.4 Classroom communication

The absence and reduction of classroom communication could be viewed as detrimental for student learning through a sociocultural perspective as social interaction is crucial for learning and cognitive development according to Vygotsky (2005). The mediation in these situations was done through a virtual classroom however these virtual classrooms had disadvantages for each of the three mediation categories. Regulatory mediation suffered due to technical issues and students' reluctance to ask for clarification, mediation by artifact (Wartofsky, 2012) was not achieved as the virtual classrooms originally did not allow for group rooms and mediation through gestures was also reduced as student's did not turn their camera on which also made it increasingly difficult for teachers to decode (Maltén, 1998) what the student wanted to convey.

Classroom communication extends further than teacher-student communication and includes communication between students. Findings showed that without virtual group rooms, communication between students was practically non-existent during distance teaching. This eliminates the possibility of establishing social norms which encourages and facilitates student learning (Skott et al, 2010). Teachers stated that the possibility for virtual group rooms allowed and emphasized discussions which is in accordance with Bennet's (2010) findings regarding the benefits of smaller classroom groups. The findings also showed that the availability of virtual group rooms came during the later stages of distance teaching which strengthens this implication as previous studies, that were carried out during the early stages of distance teaching, showed that students stated that they miss socializing with their classmates (Sveriges elevkårer, 2020; Åkerfeldt & Hermansson, 2020). As the possibility for communication in the classroom was heavily reduced before the implementation of group-rooms, the students' learning possibilities and experiences were unequal to that of a traditional classroom (Vygotsky, 2005; Skott et al., 2010; Klapp, 2015). The equivalency theory (Simonson, 1999) states that different circumstances in learning environments lead to different learning outcomes and experiences, which is in line with the findings.

7.2.5 Classroom participation

Student participation in class was negatively affected by distance teaching as the data has stated and one of the major reasons behind this was the student's freedom to control whether their camera and microphone would be turned on or off. Both from the quantitative and the qualitative data, students and teachers testified to this being the main problem that needs to change as students with cameras and microphones turned off were only present, but not actually participating in the virtual class. Potential reasons for students not participating may be that they did not find distance teaching interesting or motivating, as discussed by Hamann et al. (2012) in their study. Without participation there is also a loss of interactive relations, as Vygotsky (2005) means is the basis of learning.

The lack of motivation is especially brought forward in the qualitative data by several students with some stating that it did not feel like class due to the circumstances of their class environment, which was that barely any student was participating. Therefore participation and motivation could be dependent on each other as the lack of one implies the lack of the other. However, the problem is not as easy to solve as just establishing an obligatory rule to turn cameras and microphones on, as there are ethical aspects one needs to consider. These

could be for instance that a student is in a home environment that they do not wish to show, which is a problem that Molin et al. (2020) also explores. Regardless, the reduction of interactive participation from students will, according to Skott et al. (2010), have a negative effect on their learning.

Other reasons for the lack of participation includes students that are reluctant to answer in a virtual classroom because they experience more social vulnerability, as of the poker chip theory (Bennett, 2010) and anti-study culture (Wernersson, 2010; Zimmerman, 2019). This is especially relevant for students that started upper secondary school during distance teaching, as they may have started digital class before getting to know each other on a physical occasion. For them, speaking in front of their class full of strangers, let alone black screens, is a much higher social risk to take. The students in this class would, according to Bennett's (2010) poker chip theory, start with nearly no poker chips which is setting them up for interactive failure and a crippled ability to learn (Vygotsky, 2005; Skott et al., 2010).

7.3 Discussing the handbook

The handbook was developed based on experiences from specific circumstances. Compared to some of the previous studies where participants actively chose to participate in distance teaching (Smith et al., 2002; Safavi et al., 2013), the participants of this study experienced different circumstances as they were practically forced to study at a distance because of the global pandemic. The lack of mental preparation for distance studies can have negative effects on the students' experiences as the students have shown both in this study and previous studies (Sveriges Elevkårer, 2020; Åkerfeldt & Hermansson, 2020) in which they missed traditional teaching and wished for distance teaching to end. This is important to keep in mind when reading this report and eventually utilizing the developed handbook as students who actively choose to study at a distance may have different experiences.

The development of the handbook was underpinned by sociocultural and equivalency theories, and influenced by other mathematics didactics theories, specifically Tchoshanov's (2013) theory of the didactical tetrahedron. The key concept of the tetrahedron is to include technology into the original theories of the didactical triangle (Wahlström, 2016), therefore it was deemed not only relevant but vital to obtain the equal level of teaching in distance as in traditional teaching (Simsonson, 1999). The handbook aims at promoting distance learning by giving advice which will facilitate and promote e-Teaching and e-Advising aspects of distance teaching. However, as the handbook does not include advice for students, the handbook does not directly facilitate nor promote the e-Learning side of the tetrahedron which should be taken into consideration when utilizing the handbook (Tchoshanov, 2013).

The testing, evaluating, and improving part was a vital step in developing the handbook (Hrastinski et al., 2010; SVID, n.dc) to ensure that the study provides proper design- and development results. An optimal testing method would have been to send the prototypes to teachers that are still teaching at a distance and need guidance. However, during the period in which this study was carried out, upper secondary schools in Sweden had already returned to traditional teaching. This made testing opportunities for a handbook intended to facilitate and integrate distance teaching difficult and limited. Consequently, the method of testing the prototype instead became to share the prototype with the three interviewed teachers and analyze the feedback. Furthermore, feedback from more teachers than only the three interviewed ones could have been beneficial to establish a more generalized and extensive view of the handbook's efficacy. As the initial prototype was limited to this form of testing, the improved version will remain as a prototype of a handbook and would need further and more extensive testing with regards to how well the prototype fulfills its intended purpose.

7.4 Sustainable development and the global goals

The pandemic affected the world in many ways, one of the effects was hindering progress toward sustainable development and the Sustainable Development Goals (SDGs). Svenska FN-förbundet (2020) writes about how each of the 17 SDGs were affected by the pandemic, the most relevant for this study being goal four.

The fourth goal is *quality education* and is described as *"Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all." - United Nations (n.d.),* to which the United Nations stated that Covid-19 wiped out 20 years of educational gains. During the pandemic, schools experienced hardships in maintaining the same level of quality in education through distance learning as they previously had in traditional teaching. Approximately 80% of the countries throughout the world offered distance teaching during the pandemic and only about 61% of upper secondary schools around the world had access to the internet during 2020 (Svenska FN-förbundet, 2020). This shows that not only has education decreased but also become more unequal as children and young people from vulnerable areas are at greater risk for exclusion in schools which in turn leads to growth of educational differences. Another risk to the equality of education is how different students' learning experiences are positively or negatively affected by distance teaching. This risk has been stated in several earlier theories and studies (Mupinga, 2005; Loch, 2008; Engelbrecht & Harding, 2009) and showed itself again in this study as the findings showed that while there were some students that experienced advantages or were simply unaffected, the majority experienced negative effects on their learning experiences.

However, the pandemic and the circumstances of distance teaching came so sudden and unpredicted that most schools and teachers were not ready for it and had to improvise. Given more time schools can perhaps adapt better and be able to provide the same learning experiences online as in a physical classroom so that the outcomes of distance teaching do not underperform the outcomes of traditional teaching, which is the basis of the equivalence theory by Simonson (1999). Furthermore, if schools manage to handle the logistics and hardships of distance teaching, then schools may even be able to offer education more widely as the requirements of large school enrollments can be met in distance teaching, which

Mupinga (2005) discussed. This will help in achieving the fourth SDG which is equal education for all in a more inclusive and long-lasting way.

7.5 Method discussion

In this section, the methods chosen for answering the research questions will be discussed. More specifically, the discussions will cover the *validity, generalizability and reliability* of the methods and the respective results.

Iben Maj Christiansen (2018) describes the term validity as a measure of how well the study and its results relate to and answer the research questions. Christiansen further splits validity into *internal validity* and *external validity*. The internal validity focuses on evaluating how valid the results that come from the chosen methods are. If the method is very straight-forward and results do not have to be assumed or indirectly derived, the internal validity is high as the results are direct and not dependent on interpretations. The external validity focuses on how valid results and conclusions are for the subject outside the specific study boundaries. If the study is done with specific circumstances that affect the results then the external validity is lower as similar studies carried out would not have achieved similar results. The external validity of a study can also be called the study's generalizability. Higgins and Straub (2006) describe the reliability of a study as how close the study results and conclusions are to being factual, in other words how likely is it that these results would be achieved if the study was done again several times. For example, if the study is done with methods lacking theoretical background, continuous revising and is carried out by someone with little experience, the reliability of the study will be lower.

To improve the internal validity of the results from the study, different measures or strategies were put in place. Firstly, the use of different data-collection instruments helped in providing both statistical and textual data to help provide a holistic picture of the situation from both the quantitative and qualitative part of the study. In addition to this, the biases of the researchers did not influence the results as the presentation of the data was mostly done using descriptive statistics from the quantitative data and direct quotations from the qualitative data. However, the only miniscule risk to the internal validity of the study was that the qualitative data was collected in Swedish and was translated by the researchers to English before being presented in quotations during Section 5. This was a risk due to the researchers not having English as their first language, but the risk was minimized as the researchers were fluent in English and double-checked their translations with the help of online translating tools such as Google Translate and DeepL.

The external validity and/or the generalizability of the study is not as relatively high. This is due to the relatively low number of respondents to the surveys. This study’s survey had 80 respondents compared to similar previous studies carried out in Sweden which had surveys with 7543 respondents (Sveriges Elevkårer, 2020), 2306 respondents (Åkerfeldt & Hermansson, 2020) and 627 respondents (Strand & Thorén, 2021). While 80 respondents is not low and yields a decent generalizability, it could have been higher had the amount of respondents to the survey been higher. A total of nine interviews were carried out which is a decent amount and keeps the generalizability of the study from lowering but does not

necessarily raise it either. Finally, the 9 interviewees were distributed among 6 different schools which also helps the generalizability from lowering drastically as this minimizes the risk of interviewing people with the exact same circumstances due to belonging to the same school. Regarding the handbook, due to the limited testing opportunities, the generalizability is relatively low, and the final version was still a prototype with need for further testing.

The reliability of this study is high as the study aimed at identifying experiences and challenges of distance teachinging during upper secondary school mathematics, which it did. The survey had a high reliability as a pilot study was done prior to quality check the intended questions. The researchers carried out the study while still being students which leads to risks of lowering the reliability of the study. This risk was however minimized as the study had extensive theoretical background and the researchers continuously and frequently met with their two supervisors to make up for their potential lack of experience.

7.6 Further studies

This study has generated some interesting findings as well as thoughts on how to continue research on this study. Therefore, in this section suggestions of future studies will be presented based on the findings of this study.

7.6.1 Research

Although the pandemic has been going on for two years, this is nevertheless a relatively new area of study. Therefore, one potential way to further the studies in this area is to conduct a study on a larger scale with more schools, teachers and students involved. As this study only looked at upper secondary schools in Stockholm, future studies can take it further geographically. This way one can potentially see the differences between more schools and the extracted results can be better established with more respondents, especially since this study was a little short on the quantitative part of the data with merely 80 respondents. As far as the qualitative part, one way to take it to the next level is to interview actors on a higher level institutionally, for instance a principal or a governmental person. On a said larger scale study, one may also enlarge the subject of the study exploring other aspects with more or other questions.

One of the major findings of this study was centered around the loss of interaction aspect and how it is the biggest difference between distance teaching and traditional teaching. A way to further explore the details of this finding could be by exploring several classrooms with different circumstances and comparing them. For instance, a class with students who generally perform well in school, a class of students who generally perform poorly, a class of students with different special needs, a big class, a small class etc. One can also explore the same class but with different teachers, observing the different learning experiences for the students as per the equivalence theory. In summary, a future study could be a research of different class situations with controlled variables, to be able to draw more detailed conclusions.

7.6.2 Development

Besides the research part there has also been a development part involved in this study which is the created handbook for teachers and schools to use. This is a handbook created off of this study which obviously leads to the thoughts of whether it is practically and successfully a good handbook or not. A possible continuation is therefore to test this handbook on different schools, teachers and classrooms and evaluate the results of the testing to further develop the handbook into the best product it can be. Once the product is successful it can be released into the market while still continuously and regularly being tested in alignment with new technological and pedagogical findings concerning distance teaching.

7.6.3 Further research

The following research questions have been formulated based on the presentation in 6.6.1 and 6.6.2 about potential future research.

- What are the main differences in the experiences of distance teaching between different schools? What can be learned from that?
- Based on the equivalence theory, how can teachers provide the same learning experiences for their students in distance teaching as in traditional teaching?
- How does the utilization of the handbook affect different classrooms' experiences of distance teaching? Based on the results, how can the handbook be improved?

8. Conclusion

This study consists of two intertwined parts. The first part was the research part of the study and aimed at identifying Swedish upper secondary school students' and teachers' experiences of distance teaching in mathematics. The second part was the development part and aimed at developing a support material in the form of a handbook to facilitate and integrate distance teaching of upper secondary school mathematics. Both parts were carried out, analyzed, and discussed through a theoretical framework rooted in sociocultural theory, equivalence theory and mathematics didactics. This study has been a part of the K-ULF project and was carried out through a sequential transformative mixed-method research design of data gathering and analyzing. Background in the form of previous theories and research were gathered through literature studies, quantitative data was gathered through surveys that received a total of 80 answers from students, a thematic analysis of the qualitative data was done, and qualitative data was gathered both from the open answers on surveys and from a total of nine interviews consisting of six student interviews and three teacher interviews. The following subsections contains a short summary of the results and conclusions of both parts of the study.

8.1 Research part

The findings of the research part of the study (See section 5) revealed that students' and teachers' experiences of distance teaching of Swedish upper secondary school mathematics were predominantly negative. In the study, mathematics teaching was closely studied by, through a thematic analysis of the quantitative data, identifying five different aspects of mathematics teaching that were deemed important and relevant for the study. The five identified aspects were: general work, student motivation, receiving help from the teacher, classroom communication and classroom participation.

The quantitative data revealed that most participating students experienced that distance teaching had a negative effect on every aspect; very few experienced a positive aspect on individual aspects, and a notable portion of participants experienced no effect on every aspect. The qualitative data revealed that almost every student noted that these aspects were negatively affected by distance teaching. However, the difference between the students who stated negative, positive and no effect, respectively, was how dependent the students were on external factors on their learning.

The students who experienced a negative effect were more dependent on external factors such as teacher help, outer motivation, social aspects, and classroom communication, while remaining students were independent of these. The main difference between students who noted a positive effect and students who noted no effect, was that students who experienced a positive effect stated that distance teaching saved time as they no longer had to travel to school and enjoyed a quiet home environment while students who noted no effect were practically indifferent to the change in learning environment. The qualitative data further revealed that teachers experienced that distance teaching had a generally negative effect on mathematics teaching and student learning due to reduced opportunities to build social relations with students and communicate with them.

8.2 Development part

The development part resulted in a prototype of a handbook (See Appendix 1) that can be used to facilitate and integrate distance teaching in upper secondary school mathematics. The design process consisted of firstly analyzing the data gathered from the research part to identify and concretize challenges of distance teaching. The major challenges were reduced student work, reduced teacher presence, reduced social aspects and some teachers lacking digital competence. The minor challenges were teachers handing out too many assignments, students' lack of structure and minor technological issues. From these challenges, several potential solutions were derived such as students required to turn the camera on, utilizing group rooms, handing out group assignments, relevant technological tools and technological introductions for teachers as well as recording classes. These solutions were then summarized and presented as a list of advice for teachers and schools separately in the handbook. Lastly, the first prototype of the handbook was tested and improved through evaluation of feedback from the interviewed teachers.

8.3 Final words

There has been much to research, learn from and adapt to regarding the sudden digital transition that the pandemic forced schools and teaching institutions into during these last two years. Distance teaching these last couple of years have been a consequence of the unavailability of traditional teaching, however in the future it can very well be a viable alternative teaching form. It is important to take into consideration the many found benefits as well as disadvantages of the two forms of teaching and find a balancing definition of when and where one is more suitable, as schools in Sweden recently transitioned back to traditional teaching. It is also important to remember that as technology constantly develops, circumstances of distance teaching can change and the conclusions of this study thereby becoming less relevant. However, the researchers hope that this study, as well as other studies of this test period of distance teaching, can become something worth utilizing and help in further developing and improving sustainable and effective teaching forms.

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Appendices

Appendix 1: Handbook for distance teaching in upper secondary school mathematics

This handbook contains a collection of advice directed towards schools and teachers of mathematics of upper secondary school. It is a part of the KTH master thesis *"Swedish experiences of distance teaching in upper secondary school mathematics"* - written by Johannes Mejreh and Suheib Saleh in 2022.

Background

A consequence of the global pandemic that took place during the years of 2020-2022 was that all upper secondary school education in Sweden transitioned to being carried out at a distance. This led to a change in several aspects of teaching in general, such as environmental aspects, social aspects, and communication aspects. The change in teaching aspects further led to consequences such as challenges and difficulties that teachers and students experienced during distance teaching of upper secondary school mathematics in Sweden. This handbook is a result of a study focusing on these experiences and contains a description of major and minor challenges that were experienced as well as a list of advice for schools and teachers to take into consideration to facilitate and integrate distance teaching into upper secondary school mathematics. The challenges and advice were derived by taking into consideration the experiences, Wahlström's (2016) didactical questions and competencies that Skolverket (n.d.c) means mathematics teaching should develop.

Challenges and difficulties

Below are summarized descriptions of major and minor challenges that the study revealed from 80 student answers on an online survey and a total of nine interviews, three from teachers and six from students.

Major challenges

- **Reduced student work** - Teachers experienced difficulty in monitoring students' work as students could turn their camera and microphone off. This gave students more freedom to do other things during lectures and made them more susceptible to distractions which led to reduced student work.
- **Reduced teacher presence** - As the teachers encountered difficulty in monitoring student work and students rarely speaking or asking questions, the teacher's role diminished.
- **Reduced social aspects** - Using one big virtual classroom led to a reluctance from students regarding speaking with each other and asking questions in general as everyone in the classroom would hear what is being said, this led to a reduced social aspect in the classroom.
- **Some teachers lacked digital competence** - As the transition to distance teaching was sudden and happened quickly, many teachers did not have enough time to familiarize themselves with the digital tools which limited the teaching experience for participants.

Minor challenges

- **Students' technological limitations** - Some students experienced difficulty in showing their work when asking for help as they would work with pen and paper and would have to hold up their paper to the camera which was ineffective as it relied on camera quality and internet connection.
- **Poor video and audio quality** - Students stated that they experienced poor video and audio quality from the teacher's side which made lectures more difficult and less interesting to follow.
- **Too many assignments** - Some teachers tried to ensure that students were working by handing out an assignment every lecture that students had to turn in. This led to students becoming less motivated as they experienced an increased workload but reduced teaching quality.
- **Reduced student structure** - As students no longer had to travel to school and could turn their camera off to not be seen, students lost the aspect of getting ready for school. This led to students waking up right before a lecture started and did not mentally prepare themselves for learning as the structure was no longer there.
- **Internet troubles during lectures** - Some students experienced trouble with their internet connection during lecture time making it increasingly difficult for them to follow the lecture and in some cases unable to attend the lecture at all.

Advice

The following subsections will include advice to upper secondary schools and mathematics teachers based on experiences, challenges and difficulties found in the study.

Advice to upper secondary schools

- Teachers need to be equipped with digital tools that include good cameras and microphones to ensure good quality in their teaching.
- Teachers and students need to be provided with a digital learning platform for managing courses where teachers can upload materials and other information regarding the course.
- Teachers need to be provided with a comprehensive digital communication tool that offers the availability to create digital group rooms, drawing on a virtual whiteboard, using a virtual background when the camera is turned on and sharing your screen.
- Teachers need to be provided with extensive training regarding the use of these digital platforms before carrying out distance teaching.
- Teachers should have the right to ask students to turn on their cameras and students should have the right to use the appropriate virtual background when their cameras are turned on.
- Students with poorer backgrounds may need support with tools, materials, and potentially a place to study.

Advice to mathematics teachers

- Ask students to turn on their cameras; otherwise it will be difficult to see which students are working and which are being distracted.

- The use of small groups in the form of breakout rooms (virtual group rooms) facilitates and promotes interaction and communication between teachers and students during lectures.
- Dividing two to three students into respective virtual group rooms can recreate the table mate environment for students where they work with a student they are virtually sitting next to, which promotes and benefits communication and discussion opportunities for students.
- Handing out group assignments regularly with submissions (but not too often, once every or every other week) promotes continuous and active collaboration and discussion among students during lectures.
- A detailed study guide in the form of a schedule with details about what each lesson will include should be posted on the digital learning platform to help students structure their studies and catch up if they fall behind.
- Recorded theory presentations can be uploaded and made available on the digital learning platform to help students who potentially miss one or more lessons or fall behind.
- Short theory presentations that are available online can be uploaded or referred to on the digital learning platform to help students prepare for a lesson and look back on it if needed.

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Appendix 2: The online survey

Elevenkät

Vi heter Suheib Saleh och Johannes Mejreh och vi studerar Civilingenjör och lärar-programmet på KTH,
Kungliga Tekniska Högskolan. Vi ska skriva vårt examensarbete tillsammans med KULF (Kompensatorisk undervisning för lärande och forskning) med syfte att identifiera för- och nackdelar med digital matematikundervisning.

Vårt examensarbete kommer handla om elevers upplevelser av distansundervisning under 2020-2022 med fokus på matematikundervisning. Enkäten är frivillig och kommer användas som dataunderlag för arbetet. Har du några frågor så får du gärna kontakta oss på suheib@kth.se och mejreh@kth.se. Tack för att du deltar!

Dessa enkäter används endast för att få en generell helhetsbild och därmed är alla som svarar helt anonyma. Inga namn eller namn på skola kommer dokumenteras och det kommer inte vara möjligt att spåra en individs svar.

All insamlad data kommer att lagras på en av KTH:s lagringstjänster och sekretessprövning kommer ske innan eventuellt utlämnande av handlingar.

Samtycke *

- ◯ Jag samtycker till att delta i studien.
- ◯ Jag samtycker inte till att delta i studien.

Vilken årskurs går du i? *

- ◯ Årskurs 1
- ◯ Årskurs 2
- ◯ Årskurs 3

Vilket gymnasieprogram (Till exempel: naturvetenskapsprogrammet, ekonomiprogrammet etc) läser du? *

Ditt svar

Hur många terminer har du haft distansundervisning *

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4+

Vilken/vilka matematikkurser har du läst på distans? *

- ☐ Matematik 1
- ☐ Matematik 2
- ☐ Matematik 3
- ☐ Matematik 4

Vilken sorts matematikundervisning föredrar du? *

- ◯ Fysisk undervisning (Det vill säga på plats i skolan)
- ◯ Distansundervisning (Digital undervisning exempelvis på zoom eller Google meet)
- ◯ Ingen preferens

Om du har en preferens: Motivera gärna din preferens *

Ditt svar

Hur upplever du att distansundervisning påverkat ditt allmänna arbete (Till exempel: arbete under lektionstid och hemma) inom matematik? *

- ◯ Positiv påverkan
- ◯ Negativ påverkan
- ◯ Ingen påverkan
- ◯ Vet ej

Om du upplevt en positiv/negativ påverkan, varför var påverkan positiv/negativ? *

Ditt svar

Hur upplever du att distansundervisning påverkat dina prestationer inom matematik? *

- ◯ Positiv påverkan
- ◯ Negativ påverkan
- ◯ Ingen påverkan
- ◯ Vet ej

Om du upplevt en positiv/negativ påverkan, varför var påverkan positiv/negativ? *

Ditt svar

Hur upplever du att distansundervisning påverkat ditt intresse för matematikämnet? *

- ◯ Positiv påverkan
- ◯ Negativ påverkan
- ◯ Ingen påverkan
- ◯ Vet ej

Om du upplevt en positiv/negativ påverkan, varför var påverkan positiv/negativ? *

Ditt svar

Hur upplever du att distansundervisning påverkat din motivation (Till exempel: att lära dig mer eller uppnå högre betyg) inom matematik? *

- ◯ Positiv påverkan
- ◯ Negativ påverkan
- ◯ Ingen påverkan
- ◯ Vet ej

Om du upplevt en positiv/negativ påverkan, varför var påverkan positiv/negativ? *

Ditt svar

Hur upplever du att distansundervisning påverkat din delaktighet under lektionstid inom matematik? *

- ◯ Positiv påverkan
- ◯ Negativ påverkan
- ◯ Ingen påverkan
- ◯ Vet ej

Om du upplevt en positiv/negativ påverkan, varför var påverkan positiv/negativ? *

Ditt svar

Hur upplever du att distansundervisning påverkat din koncentration under lektionstid inom matematik? *

- ◯ Positiv påverkan
- ◯ Negativ påverkan
- ◯ Ingen påverkan
- ◯ Vet ej

Om du upplevt en positiv/negativ påverkan, varför var påverkan positiv/negativ? *

Ditt svar

Hur upplever du att distansundervisning påverkat möjligheten att få hjälp från läraren under lektionstid inom matematik? *

- ◯ Positiv påverkan
- ◯ Negativ påverkan
- ◯ Ingen påverkan
- ◯ Vet ej

Om du upplevt en positiv/negativ påverkan, varför var påverkan positiv/negativ? *

Ditt svar

Hur upplever du att distansundervisning påverkat möjligheten att kommunicera med lärare och klasskamrater under lektionstid inom matematik? *

- ◯ Positiv påverkan
- ◯ Negativ påverkan
- ◯ Ingen påverkan
- ◯ Vet ej

Om du upplevt en positiv/negativ påverkan, varför var påverkan positiv/negativ? *

Ditt svar

Upplevde du att något saknades inom distansundervisningen? *

Ditt svar

Upplevde du det fanns någon fördel med distansundervisningen inom matematik? *

Ditt svar

Upplevde du att du kunde gjort något annorlunda för att förbättra ditt lärande under distansundervisningen? I såna fall, vad? *

Ditt svar

Upplevde du att läraren kunde gjort något annorlunda för att förbättra ditt lärande under distansundervisningen? I såna fall vad? *

Ditt svar

Upplevde du att skolan kunde gjort något annorlunda för att förbättra ditt lärande under distansundervisningen? I såna fall, vad? *

Ditt svar

Vilken sorts undervisning tycker du gynnade de olika områdena inom matematik? *

	Distansundervisning	Ingen preferens	Fysisk undervisning
Allmänt arbete	◯	◯	◯
Prestation	◯	◯	◯
Motivation	◯	◯	◯
Matematikintresse	◯	◯	◯
Koncentration på lektioner	◯	◯	◯
Personligt stöd	◯	◯	◯
Delaktighet	◯	◯	◯
Närvaro	◯	◯	◯
Kommunikation	◯	◯	◯

Appendix 3: Test your idea template SVID

Testa er idé/prototyp

Konceptnamn:

Prototyp av handbok

Utvärderare/testperson:

De tre intervjuade lärarna

Relation till lösningen:

Källa för svårigheter som lärare stött på

Kommentar:

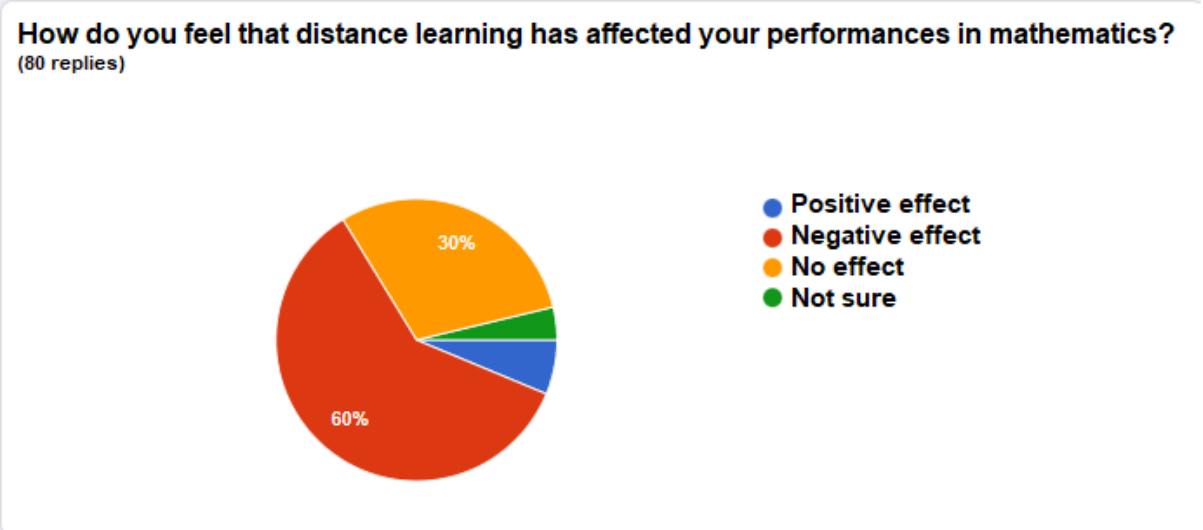
Lärare ger feedback utifrån sina erfarenheter av övergången till distansundervisning och vad de upplever hade varit gynnsamt då.

Demonstrera er lösning och ta emot feedback

Det här fungerade	Detta kan förbättras
Råden till lärare är bra och hjälpsamma **Bra separation mellan råd till skola och lärare** **Bra med råd till skolor om hur de kan hjälpa lärare**	**Inkludera allmänna råd som inte baseras på större utmaningar** **Kan bli svårt för lärare att tvinga elever sätta på kameror, skolan måste bestämma regler för detta** **Elevers hemsituationer och bakgrunder varierar och de kan behöva stöd i form av material och eventuell studieplats**
Nya frågeställningar	**Nya idéer**
Kan skolor införa krav på att elever slår på sina kameror under lektionstid? **Vilka allmänna råd kan ges till lärare för att underlätta lektioner på distans?** **Hur kan skolor stödja elever från varierande bakgrunder med eventuella stödmaterial och studieplats?**	**Elever måste ha tillgång till virtuella bakgrunder i det fallet att läraren ber dem slå på kameran** **Viktigt att läraren håller positiv attityd då elever speglar detta.** **Lärare bör testa sin internetuppkoppling, kamera och mikrofon** **Skolor bör förbereda eventuella datorer och studieplatser för elever som potentiellt kan behöva dessa**

SVID

Appendix 4: Distance teaching's effect on student's performance in Swedish upper secondary school mathematics



Appendix 5: Consent forms

Student consent form

Samtycke för medverkan i studie gymnasieelever över 16 år

Studie av Johannes Mejreh och Suheib Saleh inom K-ULF-projektet – information till gymnasieelever.

Projektet *Kompensatorisk undervisning för lärande och forskning* (K-ULF) vill bidra med ökad kunskap och insikter gällande hur undervisningens utformning bidrar till att stärka skolans kompensatoriska uppdrag. I skolans kompensatoriska uppdrag ingår att ge alla elever samma förutsättningar att nå skolans mål oberoende av kön, språkfärdigheter, föräldrarnas utbildningsnivå eller under vilken socioekonomisk miljö man växer upp i.

Vi heter Suheib Saleh och Johannes Mejreh och vi studerar Civilingenjör och lärare-programmet på KTH, Kungliga Tekniska Högskolan. Vi skriver vårt examensarbete tillsammans med K-ULF. Examensarbetet handlar om elevers upplevelser av distansundervisning under åren 2020–2022 med fokus på matematikundervisning.

Syfte och studieupplägg

Studien har två huvudsakliga syften. Det första syftet med studien är att genom enkäter och intervjuer, samla underlag för att identifiera för- och nackdelar med distansundervisning inom gymnasiematematik. Det andra syftet är att därefter utveckla en handbok som elever och lärare kan använda i framtiden för att underlätta och optimera tillämpning av distansundervisning i gymnasiematematik.

Intervjuer som sker på plats spelas in genom ljudupptagningsprogram på mobiltelefoner och intervjuer som genomförs digitalt spelas in med hjälp av en röstinspelningsfunktion på programmet Zoom. Intervjuinspelningarna kommer sedan att transkriberas av skribenterna och slutligen analyseras med hjälp av tidigare litteratur och studier. Studiens preliminära plan är att pågå fram till sommar 2022.

Dokumentation

För att samla in data och få en bättre blick på elevers erfarenheter har vi valt att utföra intervjuer. Intervjun är frivillig och resultaten kommer endast användas för att besvara studiens forskningsfrågor samt i vetenskapliga artiklar skrivna av forskare och lärare inom K-ULF. Intervjun och dess frågor är inspirerade utifrån en analys av tidigare insamlade data i form av enkäter.

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1 (3)

Deltagande i studien
Du tillfrågas härmed om deltagande i denna studie. Du kan när som helst avbryta deltagandet under intervjun utan närmare motivering. Vi ber dig fylla i nedanstående blankett och överlämna denna till oss innan eller i samband med intervjutillfället.

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Stockholm 30-03-2022

Med vänlig hälsning
Johannes Mejreh och Suheib Saleh
KTH Kungliga Tekniska Högskolan

Samtycke för deltagande i studie om erfarenheter utav distansundervisning i gymnasiematematik

Jag har läst informationen om forskningsinsatsen i KULF-projektet och samtycker till att delta i studien (kryssa i).

Ja □ Nej □

Jag samtycker också till att materialet används för fortbildning av pedagoger och lärare (kryssa i).

Ja □ Nej □

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Klass

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Underskrift

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Namnförtydligande

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Datum

Teacher consent form

Samtycke för medverkan i studie gymnasielärare

Studie av Johannes Mejreh och Suheib Saleh inom K-ULF-projektet – information till gymnasieelever.
Projektet *Kompensatorisk undervisning för lärande och forskning* (K-ULF) vill bidra med ökad kunskap och insikter gällande hur undervisningens utformning bidrar till att stärka skolans kompensatoriska uppdrag. I skolans kompensatoriska uppdrag ingår att ge alla elever samma förutsättningar att nå skolans mål oberoende av kön, språkfärdigheter, föräldrarnas utbildningsnivå eller under vilken socioekonomisk miljö man växer upp i.

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Stockholm 30-03-2022

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Ja ☐ Nej ☐

Jag samtycker också till att materialet används för fortbildning av pedagoger och lärare (kryssa i).

Ja ☐ Nej ☐

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Appendix 6: Interview guide

Interview questions students

Vilken årskurs går du och vilket gymnasieprogram läser du?

Har du upplevt matematikundervisning på distans på gymnasienivå? Isåfall hur många semestrar?

Har du upplevt fysisk matematikundervisning på gymnasienivå? Isåfall hur många semestrar?

Vilka matematikkurser har du läst och vilka utav dessa lästes på distans respektive på plats.

Vilken sorts undervisning föredrar du och varför?

Vad upplevde du var för- och nackdelar med båda undervisningsformerna?

Hur upplever du att distansundervisning påverkat *allmänt arbete*

Hur upplever du att distansundervisning påverkat *motivation*

Hur upplever du att distansundervisning påverkat *att få hjälp av läraren*

Hur upplever du att distansundervisning påverkat *kommunikation i klassrummet*

Hur upplever du att distansundervisning påverkat *participation in the classroom*

Hur upplever du att du använde din tid åt matematik under distansundervisning och under fysisk undervisning

Upplevde du att något saknades när undervisning gick tillbaka till att vara på plats?

Hur kan distansundervisning integreras till den traditionella fysiska undervisningen?

Vad kan *lärare och skola* göra annorlunda för att förbättra undervisning, både på distans- och fysisk?

Interview questions teachers

Hur länge har du jobbat som matematiklärare?

Har du undervisat matematik både på distans och fysiskt på gymnasienivå? Isåfall hur mycket av båda (antal terminer)?

Vilka matematikkurser undervisar du?

Vilka matematikkurser undervisade du på distans?

Upplever du att distan- eller fysisk undervisning är mer fördelaktig för elevers lärande?

Varför?

Vad upplevde du var för- och nackdelar med båda undervisningsformerna?

Hur upplever du att distansundervisning påverkat *allmänt arbete*

Hur upplever du att distansundervisning påverkat *motivation*

Hur upplever du att distansundervisning påverkat *att få hjälp av läraren*

Hur upplever du att distansundervisning påverkat *kommunikation i klassrummet*

Hur upplever du att distansundervisning påverkat *delaktighet* i klassrummet=

Upplevde du att något saknades när undervisning gick tillbaka till att vara på plats?

Hur kan distansundervisning integreras till den traditionella fysiska undervisningen?

Vad kan *lärare och skola* göra annorlunda för att förbättra undervisning, både på distans- och fysisk?