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Swedish EFL students' and teachers' experiences with learning and teaching mathematics in English

Degree project in English studies

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Abstract

This study is intended to explore what difficulties students and teachers in international and IB programs in Sweden encounter when they learn and teach mathematics in English. Students enrolled in these programs tend to have English as a second or foreign language, and their being taught mathematics in a language that is not their native language might limit their understanding and the possibility to communicate and express themselves in the subject. The mathematics teachers' language proficiency and the way they approach language problems play a significant role too.

The data for this study comes from individual interviews with two teachers and four group interviews with students from different secondary and upper-secondary schools in Sweden, all of whom speak English as a foreign language expect for the native English-speaking teacher.

The result shows that most of the language difficulties the students encounter in mathematics education are related to vocabulary. However, mathematical word problems were an issue too, and that was something the teachers also confirmed. The teachers used various methods to facilitate the use of English in mathematics and they too experienced some difficulties teaching it, like using the right vocabulary. However, despite the language-related difficulties the students encountered during their learning and the language-related difficulties teachers encountered with their teaching, both teachers agreed that language is not the main problem; rather, it is mathematics itself, and no matter what language mathematics it is taught in, the main issue will always, at first hand be mathematics and not language, which is something that some researchers do not agree with.

Keywords: EFL, English, mathematic, upper secondary school, mathematical word problems, EMI

Table of contents

1 Introduction

During my placement and field studies at secondary and upper-secondary schools in Sweden, I noticed the role language played for how well students perform in mathematics. The students' interaction in their second language, which was either in English or Swedish depending on what kind of group of students I worked with, the information in their mathematics books, and the teacher's language proficiency all seemed to affect how well students performed in mathematics. According to Mulwa (2014),

> Learning language involves 'learning how to mean' and hence the language of mathematics involves learning how to make and share mathematical meaning using language appropriate to the context. This in turn demands the use of appropriate language (words and symbols) whose level of difficulty is suitable to the cognitive abilities of the learners concerned. (p.264)

Swedish students studying mathematics in English as a foreign language (EFL) need to have achieved a certain degree of proficiency in that language in order to be able to communicate their mathematical ideas in a comprehensible way, which is something that is hard enough even for first language (L1) speakers.

Against this background, it is interesting to investigate the outcome of teaching mathematics in English to EFL students. There are schools in Sweden that offer IB (international baccalaureate) and international programmes that are taught in English, as well as English Schools. Most of the students in these programmes and schools have English as a foreign or second language, and their academic achievement, in e.g. mathematics, is linked to their English proficiency. It is therefore interesting to know what kinds of language difficulties and challenges, if any, students and teachers from these programs and schools encounter when learning and teaching mathematics in English, both in class and in their mathematics textbooks, and it is the factors that limit the students' understanding and their ability to communicate mathematical knowledge in English, as well as their strategies to overcome those challenges, that this study will focus on.

1.1 Aim and research questions

The aim of this study is to find out what language difficulties and challenges EFL students and teachers in Sweden encounter when learning and teaching mathematics in English. This is

done by interviewing a number of teachers and students from programmes taught in English. By doing so, I hope to be able to provide some insight in and knowledge on what role language plays in EFL mathematics education and how to effectively help teachers and students succeed in teaching and learning mathematics in English as a foreign language. This has been done, by trying to answer the following research questions:

1. What kinds of language-related difficulties do the participating EFL students claim to experience when studying mathematics in English?
2. What kinds of language-related difficulties and challenges do the participating mathematics teachers claim to encounter when teaching mathematics in English?
3. In what ways do the participating teachers overcome those difficulties and challenges to help EFL speakers studying mathematics in English?

2 Background

Since difficulties with and challenges regarding the English language that EFL students encounter in mathematics are the main concerns in this study, a brief summary of previous studies and publications on the relationship between mathematical achievement and English language proficiency will be presented below. There seems to be a consensus that a language focus in mathematics is important when the subject is taught in English to EFL students. First, however, a background will be provided on regarding English acquisition and learning in Sweden.

2.1 Swedish students' exposure to and acquisition of the English language

Swedish people generally have a positive attitude towards using and learning English, which partly has to do with the amount of exposure to English they tend to get (Lundahl, 2012, p.39). English is a global language that is widely used in all kinds of contexts, e.g. science, school, as well as television and other media (Coulmas, 2005, p.220), and many people, not least in Sweden, choose to learn it for that reason (Lundahl, 2012, p.39). Yule (2016) mentions that students in their early teens are quicker and more effective second language learners than younger children, for example, partly because teenagers are more aware and self-conscious of what and how they learn (p.188). The combination of English language exposure in Sweden and generally young teenagers' ability to quickly learn a second language are likely to be among the reasons why Swedish students tend to have a good English

proficiency. For example, over 90% of the Swedish students passed the English national test in upper-secondary school, and over 50% of them had an average grade point of C or higher on the Swedish A-F scale (Nilsson, 2019). Since English is available in many different forms in Sweden, teachers can use various techniques and materials in their classrooms to help students become better English language learners (Lundahl, 2012), and this might be another reason why Swedish students generally perform well in English.

At the same time, the Swedish educational system offers the possibility to provide English language instruction as early as in kindergarten (Skolverket, 2011). Early opportunities for interaction are a significant factor in how well students acquire and learn a language, especially if they grow up in a social environment where more than one language is used, according to Yule (2010, p.186). However, many people learn a second language later in life and they tend not to develop the same kind of proficiency as those who acquired it early in their lives (Yule, 2010, p.187). Ledibane, Kaiser and Van der Walt (2018) explain that a significant amount of comprehensible input plays a vital role in language acquisition, though they also stress that "comprehensible input is not a sufficient condition for second language acquisition" (p.5) unless it also becomes part of the intake. In other words, when second language learners develop their interlanguage, they need interaction, preferably both inside of school and outside, to focus on and understand what has been said. Yule (2010) explains that "negotiated input is L2 material that the learner can acquire in interaction through requests for clarification while active attention is being focused on what is said" (p.193). By allowing second language learners to interact and negotiate meaning, e.g. in social activities such as group discussions, where they exchange information, ideas, strategies and reflections with each other or with their teacher, they will develop their communicative competence, including the ability to produce comprehensible output (Ledibane et al., 2018, p.6).

However, as Lundahl (2012) suggests, the use of language must alert the students to how the language works, and they must participate in language activities that are slightly beyond what their language ability can currently handle. Students must be offered a context where they use the language as thoroughly as possible (p.217). That cannot happen unless teachers provide that kind of learning environment.

2.2 Mathematics as a language

A language, as Oxford Dictionaries defines it, is a "system of communication in speech and writing" used by people and it consists of a set of sounds and written symbols (Language,

2019, n.p.). To the extent that mathematics can be said to meet these requirements, it can be considered a language in its own right. Mathematical symbols, words and numbers have communicative function (Waller & Flood, 2016, p.296) and it is therefore difficult to dismiss this part.

Some researchers argue that mathematics is a universal language; meaning that no matter where one comes from or what natural language one speaks mathematics can be comprehended. The Italian astronomer Galileo Galilei once wrote that "the laws of nature are written in the language of mathematics; its characters are triangles, circles, and other geometric figures without which it is humanly impossible to understand a single word of it" (as cited in Pisano, 2015, p.235). As Waller and Flood (2016) describe it, "mathematics is composed of definitions, theorems, axioms, postulates, numbers and concepts that can all generally be expressed as symbols and that have been proven to be true across many nations" (p.295). The symbolic systems in mathematics such as variables, numerals and parameters have a communicative function, and in order to be able to communicate mathematically, one must learn to interpret them and understand their relevance (Waller & Flood, 2016, p.296).

Nonetheless, in order for students to learn how to communicate mathematically, teachers must teach their students the mathematical communicative principles. Ledibane et al. (2018) have ideas on how it goes. They propose the three perspectives for bilinguals and EFL learners for how to communicate mathematically, both orally and in writing. One is to acquire the mathematical vocabulary as a prerequisite for understanding and being able to share mathematical knowledge (p.3). Another perspective is the construction of meaning: students must learn to understand the meanings of items in different registers, both the mathematical and the everyday meanings, before they use them (p.3). The third perspective is about participating in discourse. The authors explain that communicating mathematically involves more than learning the vocabulary or constructing meanings: “it is seen as using social, linguistic and material resources to participate in mathematical practices” (p.3).

The ability to use words to explain, justify and communicate mathematically is essential for developing mathematic proficiency (Riccomini, Smith, Hughes, & Fries, 2015, p.236). This is something that Mulwa (2014) similarly implies, and explains that “mathematics involves learning how to make and share mathematical meaning using language appropriate to the context” (p.264). Furthermore, Riccomini et al. (2015) explain that "proficiency in mathematics depends on a continuous growth and blend of intricate combinations of critical

component skills such as concepts, procedures, algorithms, computation, problem-solving and language" (p.236). That is also where the idea of mathematics being a universal language stops being convincing for some researchers. Waller and Flood (2016) explain that the reason why some researchers doubt that mathematics can count as a universal language is because of the difficulties English- language learners (ELLs) encounter in mathematics (p.297). They give the example that if a non-Farsi speaking person were to see a math problem written in Farsi, would s/he be able to solve the problem? The answer is no because the person is unfamiliar with the language. The authors thus argue that limited language proficiency is a problem when ELL students or any other language learners work with mathematical problems in a given language (p.297). This is something that Macaro, Curle, Pun, An and Dearden also point out (2018). They explain that when English is used as a medium of instruction, it is supposed to become the main language to teach a subject in a context where it has a status of a foreign language. This, however, may lead to a problem in that teachers must have an understanding of the level of EMI students' English proficiency and how it may affect their performance in that particular subject (p.38). The authors explain that EMI students or L2 students are more likely to misunderstand and misinterpret the content of the subject compared to L1 students because they are less proficient (p.66), which further shows why some researchers doubt that mathematics can count as a universal language. If mathematics were a universal language, no matter what other, natural language the learner speaks, he or she should understand it.

However, Duran, Kurhila and Sert (2019) provide another perspective and explain that one must research about the pedagogical practices in EMI to understand teachers' and students' competences as well as the ways teachers interact with their students (p.3). This provides an insight into why problems can occur in an EMI classroom. There is a possibility, for instance, that mathematics teachers may not be aware of the language proficiency problems and this may somehow affect students' learning ability and may even affect their understanding of mathematical words.

Nevertheless, the Waller and Flood (2016) continue to argue that mathematics can indeed, to some extent, be seen as a universal language because "mathematics comprises characteristics that are universal such as some symbols, theorems and procedures, which are consistent and help to quantify mathematics as a universal language" (Waller & Flood, 2016, p.304). Mathematical concepts, the meaning and reason behind a mathematical answer, and the very

principles and foundations of mathematics remain consistent no matter what natural language one speaks.

2.3 Molina's approach to developing mathematical understanding through language

Adopting a rather different perspective, Molina (2012) explains that mathematics and language are "inextricably intertwined" (p.11), meaning that it is not enough to only learn mathematical terms and concepts, since comprehension is also dependent on the instructional language as such, i.e. the language used by the teacher or textbook in English. He explains that the complexities of English can negatively affect student learning, and if mathematics teachers only focus on the subject-specific vocabulary, it may prevent them from seeing other factors related to language that can affect learning in mathematics (p.11).

While mathematical vocabulary plays an essential role in mathematical problems and instructions, teachers can sometimes have a difficult time knowing how best to teach it, especially words that are not often used outside the mathematics classroom (p.12). Molina explains that for students to understand vocabulary, learning the definition is not enough; they need to think about it, discuss it and practice how to use it. Even though there are some mathematical words that are hard to use outside math class, like *divisor* or *quotient*, which is what separates the mathematical language from everyday language, they are still important enough to explain and to learn. However, as he explains, the "inherent problem of defining abstract mathematical concepts reinforces the need to define mathematical terms in context" (p.13).

Another challenge in relate to the English language is polysemous terms, which have multiple meanings or definitions. Words such as *difference* and *product* can both have mathematical meanings and be used in a more everyday sense (p.13). To complicate matters further, some polysemous terms such as *degree* do not only have different meanings in everyday use but also different definitions *within* mathematics, where *degree* can refer to an angle in geometry, the complexity of an equation in algebra, or a unit of temperature (p.14). Since vocabulary knowledge correlates with mathematical reading comprehension, Molina maintains that the introduction and clarification of specific vocabulary is crucial.

Other challenges for EFL students can be caused by words that have similar pronunciations or/and spellings but different meanings, especially "if students do not have a context to assist

them or if the information is oral rather than written" (p.14). For example, hearing words such as *sum* and *some* together in a sentence can confuse EFL students (p.14). The same is true of ambiguous and idiomatic expressions in mathematics instruction: *reduce*, for example, which means 'make smaller' in everyday usage, can be confusing when students work with fractions, and Molina (2012) maintains that in such a context *simplify* should be used instead (p.24). *Borrow* in the context of subtraction is another example that can confuse EFL students, because if they *borrow* a number from one column in subtraction, they might think they should return it too, so that *regrouping* is a more appropriate term to use because it explains the process better, according to Molina. Similarly, *find the value of x* is clearer than just *find x* (2012, p.24). In other words, teachers must be mindful of the language to avoid confusion, and they "must be cognizant of both the overt, glaring problems created by the merging of mathematics and language as well as the more covert and subtle problems created by the nuances of the two areas" (p.20). It is a challenge for teachers to address the language issues in mathematics, but it all starts from being aware of and paying attention to the issues to be able to help EFL students succeed in the subject (Molina, 2012).

2.4 Linguistic complexity in mathematics assessment and the performance of English-language learners

Martiniello (2010) studied the linguistic complexity in fourth-grade mathematics tests taken by English-language learners (ELLs) in the US. Martiniello (2010) argues that the kinds of assessment that ELLs in the USA are submitted to do not really reveal their mathematical skills; they mostly show their English proficiency (p.1). While it has been argued that language skills should be separated from subject area knowledge, Martiniello claims that it is difficult to do so, because all ELL students' assessments in the US are done in English.

Despite Martiniello's focus on younger ages, the connections between language proficiency and mathematical achievement in her research are relevant for my study as well. If ELL students are to succeed in solving mathematical word problems, it requires them to decode "the various semiotic modalities that make up the language of mathematics" (2010, p.2). It means that ELL students must first comprehend the natural language in mathematics texts, and the more complex the text is, the more difficult it will be to process and interpret, which in turn will make problem solving more difficult than it already is. But since ELL students have not acquired English as well as their native-speaking peers, their language proficiency will partly affect how well they will perform in mathematics. In addition, Martiniello points

out that all students need to know not only the specialized vocabulary and typical syntactic structures of mathematics, but also the non-linguistic mathematical symbols to decode mathematical meaning (p.2).

Against this background, Martiniello (2010) carried out a study of a fourth-grade mathematics test. She conducted textual analyses to examine the non-mathematical linguistic complexity in the text. She also did think-aloud interviews with fourth-grade Spanish speaking ELLs, to investigate what reading comprehension challenges they encountered while solving the test (p.2).

The results showed that vocabulary commonly known to native English speakers could be difficult or unfamiliar to the ELL fourth-graders. Words such as *chores* or *certain* that ELL students rarely used at home were difficult for them, compared to words like *pencil* or *ruler*, which they learned in school. Similar difficulties occurred with polysemous words in relation to the syntactic structure in a sentence; the learners could confuse *one* as a pronoun and as a numeral, for example. While they did recognize some of the morphological relationships between the English words in the test and the Spanish words they knew, as in *impossible-imposible*, difficulties occurred where the Spanish words were less familiar, as in *certain-cierto*. Another thing that affected the ELL students' reading comprehension was that the sentences in the test had complex, multi-clausal structures with embedded adverbials and relative clauses, as well as long phrases with embedded noun and prepositional phrases, all of which "obscure the syntactic parsing of the sentence" (Martiniello, 2010, p.11).

Riccomini et al. (2015) argue along the same lines as Martiniello and explain that vocabulary learning and understanding is an essential part not only of students' language development but also of their mathematical proficiency: "the language is a pivotal component of mathematics success and a student's general knowledge of mathematical vocabulary can predict mathematical performance" (p.236). Martiniello draws the conclusion that teaching mathematics to ELL students should not be separated from them learning the language: "teachers of ELLs must provide sustained linguistic scaffolding for ELLs while encouraging the process of mathematical meaning-making" (2010, p.14). The important role of language in mathematics is to communicate mathematical ideas, and mathematics teachers should both attend to content instruction and language development to help ELL students with their achievements in mathematics.

2.5 Language and modelling word problems in mathematics among bilinguals

Compared to Martiniello (2010) and Riccomini et al. (2015), Bernardo (2005) contributes another perspective regarding the link between language difficulties and students' mathematical achievement, by comparing students' results on a mathematical test that they had done in two different languages. In his study he addresses "the matter of the relationship among learning, knowledge, and language by investigating the effects of using Filipino-English bilingual students' first and second language in solving word problems in arithmetic" (Bernardo, 2005, p.415). He explains that the reason why he chose to focus on mathematical word problems in his study is that word problems are an important part of mathematics education: the efforts to measure students' mathematical achievement rely heavily on word problems and they also have a linguistic component that can affect students' understanding (p.415). In his study, fourth-grade students who all spoke and understood both English and Filipino participated. They were given 18 English and 18 Filipino written problems and asked to solve the problem in the way they preferred (p.419). They had a few problems that were identified as easy word problems while the rest were identified as difficult word problems. The result showed that students who had Filipino as a first language and students who had English as a first language were equally successful in solving simple mathematical word problems, but Filipino speaking students were not as successful in solving more difficult problems, regardless in what language the problems were in. Bernardo (2005) explains that it may have been the case that the English-speaking students were better in mathematics and that it is therefore problematic to draw the conclusion that language had a part in it. He acknowledges that it is indeed essential to understand and comprehend textual propositions of word problems, but he further explains that,

> Our understanding of the role of language in word problem solving among bilinguals cannot be captured in a simplistic proposition about the relationship between language and problem solving. Instead, the role of language in the word problem-solving process is defined in relation to the specific components of the process. There are components of the process that are more closely tied to linguistic processes, and, thus, linguistic factors are likely to have an influence on the successful execution of the process. […] There are components of the word problem-solving process that are mathematically abstract in character, and

> thus, linguistic factors are less likely have an influence on these processes.
> (2005, pp.441-442)

He thus concludes that the mathematical language itself can be a problem when working with mathematics problems, as opposed to the natural language spoken by the student, which is what Martiniello (2010) and Riccomini et al. (2016) seem to emphasize.

3 Materials and methods

The aim of the present study is to investigate what kinds of experiences and difficulties mathematics teachers have had in teaching mathematics in English to EFL students and what the EFL students have experienced while being taught mathematics in English. Based on this aim, a series of individual interviews with teachers and group interviews with students have been carried out. The details regarding the data collection and method of analysis will be presented below.

3.1 Informants

Teachers teaching mathematics in English at various Swedish secondary and upper secondary schools were contacted and asked if they would be interested in participating in this study. They were also asked if they would be interested in letting their students participate as well. Two teachers were interested in being interviewed, though only one of them wanted their students to take part in this study. One of the teachers is a native English speaker that teaches mathematics at a secondary school where most of the instruction is in English (T1), and the other one is a native Swedish speaker that teaches mathematics in English within an upper-secondary IB program (T2). 14 students from international and IB programs in grades 10 to 12 volunteered for this study, all with English as a foreign language. They were divided into groups called G1-G4 in this study. Two of these groups came from an international economic program taught in English but following the Swedish curriculum. The two remaining groups came from an IB program, which is a three-year international pre-university program taught in English. All students have learnt English since first grade and have been studying mathematics in English since they started their upper secondary programs, except for a few students that previously went to an English School and had mathematics education in English already then.

3.2 Data collection

The two teachers that participated in this study were interviewed separately during their leisure time. The interviews lasted 20-40 minutes and were recorded with a mobile phone. The 14 students were divided into four groups of three to four participants. Each group was interviewed for 20-40 minutes in an undisturbed environment and at a time that the teachers decided was fitting. The informants sat in a circle to discuss my questions. In two of the groups, I placed a mobile phone in the centre to record their talk. Two groups of students did not feel comfortable being recorded, so I took notes while interviewing them. The interviews with two of the groups and one of the teachers were conducted in English, while the remaining interviews were conducted in Swedish because the informants felt more comfortable speaking in their native language. According to Bryman (2008, p.449), the advantage of group discussions is that the informants have the opportunity to discuss and share their opinions with each other. Conversely, however, there is the possibility that some informants will be unwilling to share their opinions or information with other informants, depending on what questions are asked. Appendix 1 features the questions for the mathematics teachers while Appendix 2 shows those posed to the students.

3.3 Method of analysis

Thematic analysis was used for analysing the collected data. It is a flexible method that helps to identify, analyse and report patterns of themes in interview data (Braun and Clarke, 2006). From the recorded interviews, the parts pertaining to this study were transcribed. These parts, together with the notes from the non-recorded interviews, were analysed. The results were sorted into recurring themes in the students' and teachers' answers that relate to English language difficulties in mathematics.

3.4 Adherence to ethical research principles

The study was conducted based on the two ethical principles emphasized by Tivenius (2015): confidentiality and informed consent. In accordance with these principles, the participants were informed about the purpose of the study before the interviews, and that they could decide at any time to withdraw their participation and/or refuse to answer a question. They were also informed that their personal information would be protected so that no unauthorized person would be able to access it. The teachers were aware of what I was studying and since

the students were all legal of age, the guardians' signature was not needed. Details regarding the participating schools, classes, teachers and students have not been provided in order to protect the participants' identity. This is something vetenskapsrådet (2017) proclaims and explains that a researcher has the responsibility for and obliges to inform the participant/s on what they are in for, how they are protected and what the study is about in order to conduct an ethnical and moral research (p.12).

4 Results

The results of the interviews will be presented according to common themes found in the informants' answers. Quotes from the interviews will be used to support the claims being made. Where appropriate, the quotes have been grammatically corrected or been translated from Swedish to English for the sake of accessibility. Since this study focuses on language difficulties and challenges teachers and students encounter when teaching and learning mathematics in English, gender and grade differences between the informants seemed to be of limited relevance and will not be focused on, only their experiences. The teachers will be referred to as T1 and T2 and the student groups as G1-G4.

4.1 Teachers' experiences with teaching mathematics in English

4.1.1 Struggles in teaching

Both teachers had similar experiences of teaching mathematics in English and they both agreed that vocabulary was an issue, but also the manner of speaking more generally. One of them said that:

> When you speak to students, sometimes you tend to start speaking fast, because you do get your temper when you get into a momentum and then you start talking too fast and that can be very difficult for second language learners to pick up. There is a certain tone you use when you speak your mother tongue and that is not always the same tone as when you speak English. So they do interpret certain statements differently. (T1)

This teacher also said that:

> Use very basic words, not big and complicated vocabulary and be very specific, because students who have English as a second language do not

> have as much vocabulary knowledge as a native speaker and that is something some teachers forget. (T1)

The other teacher had similar issues and explained that:

> With mathematic lessons taught in English one must be very prepared and be aware of what vocabulary to use, because students can easily misunderstand them. Sometimes it is not the mathematic vocabulary that is an issue when I teach, it is instead regular everyday English words that can be problematic, especially if you are not a native speaker yourself. Sometimes I forget simple words like *pärm* and that can be annoying. (T2)

The teacher continued to explain that:

> I must also sometimes remember to use the right synonym when I teach, especially with the international programs who are not used to the English environment as the IB students are. (T2)

Overall, both teachers agreed that vocabulary and using the right words were problematic for them as teachers and it was something both focused on, especially when teaching non-native English-speaking students.

4.1.2 Struggles in class and study materials

Except for mathematics in IB, the interviewed teachers taught mathematics in English but used Swedish mathematics books that correspond to the Swedish curriculum. The reason why both of them used Swedish textbooks and tasks was because:

> The formulations in English mathematics books that are available on the market were only suited to native speakers. We had a problem sometimes to distinguish what they were talking about or how they explained something. Some mathematical problems needed to be reformulated and even translated into Swedish. That is why we chose to have Swedish mathematics books and do tests in Swedish instead. (T2)

The teacher continues to explain that:

> In IB it is different, their mathematics book is written in a way that suits non-native speakers. Also, in Swedish mathematics books, they give you

> multiple problems to solve, while in English mathematics books, you only get a few and then move on to the next issue, and that can be difficult if you have language problems or if you haven't understood the problem correctly. Thus when IB students don't know a word the responsibility is put on them to find out what it means or they can talk it through with each other. (T2)

The other teacher (T1) had a similar experience and explained that they changed their mathematics books from British mathematics books to Swedish ones because students struggled with its language and its structure. The teacher furthermore explained that they have refugees in the school that are learning Swedish, and they do not want to pressure them to speak English, especially those who are not used to being taught in English. However, they continue to have tasks and quizzes in both Swedish and English.

While both the teachers agreed that it was better to use Swedish mathematics textbooks, they also pointed out that language issues occurred mostly when students worked with mathematical word problems. According to one of the teachers,

> Mathematical word problems can have language-related problems, but English should never be a problem, because it is the mathematical issue that students should focus on and not the language part. (T2)

The other teacher agreed to some extent and explained that mathematical word problems can be an issue and that one cannot teach students how to solve them; teachers can only help students learn how to target them and give them simple steps on how to break them down, but they cannot show them how mathematical word problems should be solved. That will only hinder them from actually learn and understand the problems themselves.

4.1.3 Overcoming difficulties

While both teachers had similar struggles they also thought they knew how to overcome them and work with them. One of the teachers mentioned that:

> One should prepare very well, don't talk so much, let them speak and do group work with them if they have language difficulties. (T1)

The same teacher said that:

> The best way to teach English I found, vocabulary-wise, is to let students highlight words that they don't understand and then write them on the board

> so that we can talk about them. A cross-curriculum thing is also something you can do. Word problems can go very nicely with English comprehension.

The teacher gave an example of cross-curriculum activities, where English teachers can provide a comprehension piece that has a lot of statistics in it and both English and mathematics teachers can formulate questions about it. This is something the other teacher likewise talks about:

> We haven't had the time to integrate English into math, because mathematics itself is a problem. But we can have English-based problems that students can translate. If we talk about a proof or mathematic reasoning, the English teacher can demonstrate how to correctly formulate and communicate it in English. (T2)

However, the teachers agreed that English is not the main issue in mathematics,

> To have support from an English teacher does not make that much sense, because the thing with math is that you have to learn and practice it (T1) and mathematics can be taught anyway, but it does not rely on language. English is not the concern; it is mainly about mathematics itself and what struggles students have with it. (T2).

They both agreed that mathematics is a language of its own and do not see it having any connection with English or any other languages.

4.2 Students' experiences with studying mathematics in English

4.2.1 Experiences with mathematics in English

The students' experiences with learning mathematics in English varied. Some of them thought it was a hard transition from Swedish to English, but they eventually got used to it. By contrast, others said things like:

> For me mathematics is challenging and not the language, because I'm used to English and understand the structures in English but not the math itself. (G1)

Other students agreed to some extent and explained that learning mathematics in English in the classroom while having Swedish assessments and textbooks can be very confusing. At the same time other students said it is good to have mathematics books in Swedish because they

are easier to understand. In fact, that was one reason why they did not choose the IB program, for example. Others explained that:

> Vocabulary was hard in English at the beginning, but when the teacher began to use synonyms and explained them, it got much easier. (G3)

Students also pointed out that:

> Having mathematics in English is much better because we are able to find information much easier and it is available everywhere, like Khan Academy and YouTube, and we can easily translate words. (G2)

4.2.2 Problems in tasks, textbooks and lessons

When it comes to difficulties and challenges, students all had similar experiences. Some of them thought that the vocabulary that the teacher uses during lessons can be difficult, as is also the case in their textbooks and in their assessments. Some words either have multiple meanings or they are not explained properly. Others had problems with formulations and expressions and difficulties with mathematical word problems:

> I remember one specific math problem; it was like a specific word that told you what it was but I had never heard it before. It was a tent but it was another word for a tent, which I did not know and you could not visualize what you were supposed to calculate. I think that plays a role; you need to know what the word means. (G1)

> I think word problems are the hardest part. That is when language plays a role and it kind of makes it hard to understand the actual question or what you are going to do. Like you do not know how to approach the problem. (G4)

> Most of our issues or for me anyway comes from word problems. They are hard to understand, for example the formulation and they use weird words and they make you confused and you end up not knowing how to solve the problem. (G1)

> Sometimes it is hard for me to understand and send the idea that I'm thinking about, or how to formulate. It is easier to receive than to send. It also depends on how I solve a problem and how complicated it is. (G1)

Mathematical word problems are clearly what these students have difficulties with, which is what the interviewed teachers, to some extent, agreed that their students have. According to the teachers, it is not the language that prevents their students from solving mathematical word problems; it is, however, due to the lack of knowledge on how to approach them. Still, these students explained that math word problems are formulated in a difficult way and have a formal language that prevents them from distinguishing the mathematical part of the problem, and this is a different perspective than from the one the teachers proclaimed.

However, other students thought that they did not have any problems expressing themselves and communicating in English, but mathematics itself can be a problem and having to use two different languages in mathematics can be confusing and it is better to use only one of them.

All these students had similar experiences and struggles. What can be pointed out is that the difficulties mostly occurred when students worked with word problems and encountered unfamiliar vocabulary. However, many of them pointed out that mathematics is the main issue and not the language it is presented in.

4.2.3 Solutions to the problems

Although some students had encountered language-related difficulties in mathematics, several of them also gave solutions and options on what the teacher can do in order to overcome those difficulties. Some of them suggested that the teacher could use different synonyms or use less difficult vocabulary to make it easier to understand them. Others saw an advantage in learning mathematics in English instead of Swedish and explained that:

> The advantage with learning mathematics in English is that you can always go on YouTube and find your answer. But some mathematics courses are hard and complicated and it would be a great advantage if you had good English proficiency. The vocabulary and the language are more difficult. So if someone who doesn't know English so well and would start having our mathematics, they would have huge problems. (G2)

What can be pointed out is that students thought that the beneficial part of learning mathematics in English is all the information that can easily be accessed, compared to if it was in Swedish. One important aspect that some students also pointed out and agreed on is that vocabulary and terminologies should be presented and explained, preferably with the help of synonyms too.

5 Discussion

The possibility to generalize the results from this study is limited because so was the number of participants. The discussion and conclusion that follow may therefore be primarily an inspiration for future studies or aspects to reflect further upon.

5.1 Discussion of results

The results from this study will be discussed in relation to the three research questions posed at the beginning, namely:

1. What kinds of language-related difficulties do the participating EFL students claim to experience when studying mathematics in English?
2. What kinds of language-related difficulties and challenges do the participating mathematics teachers claim to encounter when teaching mathematics in English?
3. In what ways do the participating teachers overcome those difficulties and challenges, to help EFL speakers studying mathematics in English?

Starting with EFL students' experiences, it is quite clear that most of the language difficulties they encountered when studying mathematics in English regarded the vocabulary. It could be anything from mathematics-specific to everyday English words, which is in line with what Martiniello (2010) and Riccomini et al. (2015) emphasized, namely that vocabulary learning plays an essential part in both students' language development and their mathematical proficiency. Without really understanding the meaning and function of words used in their classrooms or their mathematics textbooks, it will be hard for students to distinguish what to do or how, even if they are good mathematicians. As Molina (2010) points out, students must think about the new words they learn, discuss them and practise how to use them, because only learning the definitions is not enough if it is expected from students to express themselves and communicate mathematically.

What was even more evident was that the actual language problems mostly occurred when students worked with mathematical word problems, where the focus is firstly to analyse and grasp the text as such and then identify the mathematical aspect. This includes students from the international programs that were taught mathematics in English, though their textbooks and assessments were in Swedish. These students, too, thought that they had language problems when they worked with mathematical word problems. The question one should ask

oneself is whether mathematical word problems only pose a challenge for non-native speakers or whether it is a global issue, meaning that regardless of the language mathematics is taught in, students will always struggle with mathematical word problems. In the case of students from the international programmes, their problem is either the mix of Swedish and English they have in their classroom, making them confused about the vocabulary, or they have genuine problems with mathematics as such. This is something Bernardo (2005) mentions in his study, explaining that the problem with mathematical word problems does not necessarily rely on language itself, but could also be due to the fact that one must reason abstractly, i.e. it is a mathematical challenge. However, word-problems can have linguist components that are important to understand, such as *a tent,* which was one example given in one of the groups. For that student, mathematical word problem solving got difficult when they did not know that the word they read meant "tent", and it made it impossible for them to visualise what to do. Thus, again, from what students have said, the English language has, to some extent, a significant role in their mathematical understanding.

When it comes to the mathematics teachers, they did not think they had problems with teaching mathematics in English. According to them, it was mainly a matter of carefully planning and using right vocabulary in English, speaking in the right pace, and being very specific when explaining something because students can easily misunderstand, especially if English is a foreign language for them. Both teachers agreed that mathematics is a language in itself, and that regardless of the students' first language, they can still succeed in mathematics. To some extent, this is true, because mathematics has a symbolic system that can be globally understood (Waller & Flood, 2016, p.296). However, their answers can seem contradictory because when it came to mathematical word problems, both teachers agreed that language issues occurred there. However, they still thought that language is not an obstacle, and it is mathematics in itself that is the big problem. In other words, it seems as if these two teachers do not understand the potentially significant role English has in mathematics education, especially in mathematical word problems. Just like Bernardo (2005) mentioned, mathematical word problems could either have language-related or mathematics-related issues. Either the problem is wrongly formulated or is mathematically too abstract. But if mathematic teachers do not understand what kinds of language-related challenges mathematical word problems can contain, students will continue to have difficulties solving them, especially if teachers themselves are the ones that create them for their assessments,

because if mathematic teachers are not aware of these problems, they will continue making the same mistakes; creating incomprehensible mathematical word problems.

While both teachers had ideas on how to integrate English and mathematics education in cross-curriculum activities, it seems they still need to be more mindful about pitfalls regarding the English language, even if students are good English speakers. Then again, theses teachers speak from experience, and they are mathematics teachers, which can be a reason why they cannot fully see why the English language is essential when mathematics is taught in English.

6 Conclusion

Regarding the way this study was conducted, some methodical aspects may have affected the results. One of them is related to the interview questions. They were very similar to each other and quite specific, which prevented answers to be broader and open, so in hindsight it could be argued that it should have been more elaboration and open questions. I was lucky enough to have found teachers with great experiences that gave me rich answers, more than I had expected to get, but there was a risk of not getting as much too.

Secondly, students can sometimes take everything literally compared to teachers, because teachers will normally have developed an enhanced ability to apply different perspectives and understand people's intentions, so I had to be very specific when the students were interviewed. I am not an experienced interviewer, and certain things did not come to me naturally, meaning that I did not pick up on every detail they provided, which could have given me more things to talk about regarding their experience. Two interviews were not recorded due to the participants' request, and unfortunately, some essential aspects slipped through when the discussion was on, and I did not have enough time to write them down.

Furthermore, there were always few students from each group that brought up mathematical problems instead of English language related problems. During the interview they talked more about the mathematical issues rather than the language part, and they needed to be guided back to my questions and the focus of the study a couple of times. Unnecessary amount of time went by discussing unrelated matter, even though there were good discussions.

Moreover, not many teachers had the time or inclination to volunteer for this study, which is a pity because they could have provided more ideas, thoughts and experiences, especially if they had been both English and math teachers.

Nonetheless, this study aimed to find out what language difficulties students and teachers from upper-secondary programs in Sweden encounter when teaching and learning mathematics in English. As the results showed, students had some problems with vocabulary but the main issue was mathematical word problems. Likewise, the mathematics teachers from these programs were aware of these problems and tried to help their students in various ways. However, on the basis of their answers, it seemed that the teachers had not understood the impact language can have on understanding in mathematics. It is not necessarily about not knowing the mathematic-specific vocabulary or everyday English words, because that can occur in any other subject, including English itself. The issue here is to understand what linguistic difficulties exist in mathematical word problems. As it was shown in the national test results for the subject of English (Nilsson, 2019), Swedish students tend to have a good English proficiency and are good readers, so why are mathematical word problems an issue? Is it because mathematics teachers write texts that are too abstract, or because students have language problems, or is it mainly a mathematical issue? As this study only touched upon a little part of the general issue, it will be interesting to investigate further why mathematical word problems can be a challenge. Even so, it was interesting and relevant to research if language can have any impact on how well students perform in mathematics. Researchers have different opinions regarding the link between students' English proficiency and mathematical achievement. In a sense, mathematics is a universal language communicated through symbols and numbers, but often natural language, too, is needed to express, show, distinguish and prove something in mathematics, and that is when proficiency in such a language plays a significant role as well. On a further note, research about how English language teachers and mathematics teachers can work together might be very essential regarding issues discussed in this study. Language awareness in subjects like mathematics is necessary. Further research on English teachers' support and ideas to help mathematics teachers with their language awareness in their subject is something that is needed.

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Appendix 1: Interview questions for teachers

Introduction (background information)

- How long have you been teaching mathematics in English to students who don't have English as their first language?

Main questions

- Do you have any experience of teaching mathematics in English to students with English as their first language?
    - If yes, are there any differences between teaching mathematics in English to students who have English as a foreign language and as a first language, respectively?
    - What kind of differences have you encountered?

- What kinds of language difficulties have you noticed EFL students have had in mathematics education?
    - Difficulties in the classroom when listening, speaking and discussing?
    - Difficulties in their mathematics textbooks and assessments?

- What kinds of challenges and issues have you encountered as a mathematics teacher when you have taught mathematics in English to EFL students?
    - How can one as a teacher overcome those challenges and issues?

- Do you think there is a link between students' English proficiency and their mathematical achievement?
    - Can you explain further why you think there is such a link or why there is no link?

- What should one think about when teaching mathematics in English to EFL students?
    - Do you think that working closely with an English teacher can be of help when teaching mathematics in English to EFL students?

Appendix 2: Interview questions to students

Background information

- For how long have you studied English?
- For how long have you studied mathematics in English?

Main questions

- What is your experience of studying mathematics in English?
    - Do you think studying mathematics in English is difficult and challenging? If yes, can you further explain why it is difficult and what kinds of difficulties you have encountered?

- Do you think studying mathematics in English is hard compared to doing so in Swedish (or your native language)?

- Do you think that the language in your mathematics lessons, tasks and textbooks is comprehensible enough or do you think that it is difficult to understand?
    - If you think it's difficult, what is difficult and challenging for you?

- How do you experience it when you are obliged to express yourself and discuss mathematics in English in the classroom, when it is not your native language?

    - Do you think that you are able to show and express your mathematical knowledge well enough when you are obliged to express it in English?
    - Would it be easier to express your mathematical knowledge in Swedish (or your native language) instead?

- What do you think your mathematics teacher should think about when they teach mathematics in English? How could they make the study of mathematics in English easier?