Bilingual students' mother tongue

A resource for teaching and learning mathematics

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This article presents some of the main results of a bilingual mathematics teaching project, which run in five multicultural schools in Sweden. The main research question was: How do mathematical practices emerge in bilingual mathematics classrooms? In the project bilingual mathematics teachers seemed to promote mathematical learning and engagement in the classroom by using two languages in mathematical discourses. Pupils and teachers communicated mathematically in different ways, and the interplay between mathematics and language often became obvious. Bilingual pupils participating in the project expressed that they were able to learn more and they felt secure with the ways of using languages and learning mathematics. Participating in the project gave many of the pupils' confidence in their mathematics learning competence.

The aim of this article is twofold. On the one hand, I will describe shortly the general characteristics of a bilingual mathematics teaching project in multicultural environments in Sweden. On the other hand, I will present the main results of the investigation that has followed the project (Norén, 2007) and give examples from the qualitative study on the effects of the project on mathematics education in the participating schools. I am interested in arguing that, despite the dominant discourse in Sweden at the moment, of insisting on the benefits of monolingual instruction for all ethnic minority groups, the results of the project and the study evidence that bilingual teaching can be beneficial for the students in terms of their mathematical learning.

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I will present some of the main characteristics of the project and the actions undertaken. I will then concentrate on presenting some of the main theoretical ideas supporting the use of bilingualism to overcome deficiency models to tackle multilingual students' low achievement in mathematics. I will then present the general methodological principles of the research behind the project and focus on the analysis undertaken. I will present examples of the main results of the project in three areas: mathematics curriculum and mathematical discourse, textbooks and word problems and classroom discourse. I will conclude by pointing to some general comments on how the approach promoted by the project can improve the teaching and learning of mathematics for minority students.

The Mother tongue teaching of mathematics project

In Stockholm, Sweden, and its suburban schools there are approximately 35 % minority or migrant pupils, in some schools up to 98 %. Their origins are from different countries and together they speak more than 100 diverse languages. During the last years a lot of new pupils from Iraq and Somalia have arrived to schools.

Five suburban schools in Stockholm, with immigrant pupils between the ages of nine and sixteen, participated in the *Mother tongue teaching of mathematics project*[1]. The project was initiated by the city of Stockholm as a way to give schools opportunities to teach mathematics bilingually. Schools could voluntarily join by sending in a project plan. A team of project leaders endorsed the plans from schools and the schools accepted got economic support for paying the bilingual teachers' involvement in the project. The project was in progress for two full school years, 2004–2006, and focused on immigrant pupils who had recently arrived to Sweden, but also on immigrant pupils who had been in Sweden for a longer time. Students with their mother tongue as their most developed language took part in the bilingual mathematics teaching. Their teachers of Swedish as a second language decided who should participate. The five schools had classes teaching and learning mathematics in both Swedish, and either Arabic or Somali. The main aims of the project were to enable pupils to develop their mathematical knowledge and competence, to reach higher levels and get better grades in mathematics, and to use and develop their bilingualism in a mathematical learning environment. Eight bilingual teachers and about 60 pupils participated in the project.

In the schools participating in the study, three different organisational models were used for teaching and learning mathematics:

- All instruction was carried out by a bilingual teacher.
- The students had half their lessons in Swedish with an only speaking Swedish teacher, and half in their mother tongue with a bilingual teacher.
- Mother tongue teaching involved extended time and it was done in addition to the regular teaching, which took place in only Swedish.

Even though eight teachers taught bilingually in the project, examples in this paper derive from three of them teaching mathematics in three different schools. Bilingual students in eighth and ninth grade had all mathematics instruction with Arabic and Swedish speaking mathematics teachers. These teachers had several years of experience in teaching mathematics in only Swedish in the same schools. Before the project started the third teacher referred to in this paper used to teach Somali, as a mother-tongue subject, to Somali speaking students from third to fifth grade. Within the project he taught mathematics to bilingual students' two hours a week, in the same grades. His students had the other two hours of mathematics in only Swedish taught by another teacher.

Bilingualism and mathematical learning

Recent studies around the western world show that minority students with different linguistic and cultural backgrounds achieve poorer results in mathematics than majority students (Secada, 1992; Johansson & Emanuelsson, 1997; Skolverket, 2007). National studies in Sweden, as well as PISA and TIMSS[2] studies have shown that several immigrant pupils in Sweden don't attain even the lowest curriculum objectives in mathematics. Pupils' differences in mathematics achievement have become wider and there are concerns about minority students' marginal performance in mathematics in Swedish mathematics classrooms (OECD, 2006). Often students' low performances in mathematic are attributed to students' deficiencies that call for remediation in the students themselves, in their languages or in their cultural backgrounds. One example of this attributionist approach to minority students' school achievement is their "lack of Swedish-ness" (Parszyk, 1999; Runfors, 2003; Haglund, 2005).

Migration enforces teachers to take into account that mathematics and mathematics education are very much dependent on language and culture, as minority students often do not succeed in school mathematics (Johansson & Emanuelsson, 1997; Skolverket, 2007). Barwell, Barton and Setati (2007) argue for the great importance of recognising that "language and multilingualism in particular, interact with learning

mathematics" (p. 115). Moschkovich (2007) says that early studies of bilingual students learning mathematics often focused on word problems translating from the language of instruction to mathematical symbols. Students' vocabulary and reading skills in the language of instruction were also a point of attention. Most studies until recently have been targeted towards bilingual or second language learner students participating in monolingual instruction mathematics classrooms. Results have shown that it is a complicated task to learn mathematics in a second language one not is academic proficient in and to develop mathematical skills and mathematical communicative competence at the same time. Adler (2001) notes that it can be difficult for students to communicate mathematical ideas and concepts when instruction is done in a second language. The students might be discouraged to express and develop their own ideas as exchange of ideas is more difficult on a language that one does not master. It can also be difficult for teachers to know how clear or transparent to be in explanations and instructions, as an implicit instruction might cause students to focus on how to express ideas and concepts instead of on how to express the meaning of ideas and concepts. Adler investigated bilingual teaching of mathematics in South Africa. The teachers used students first and second languages in teaching mathematics – they code switched. She focused on three dimensions in multilingual mathematics classrooms: pupils' access to the language of instruction, pupils' access to specific mathematical discourses, and discursive practices in school and classrooms. She also discussed the benefits and risks in code switching. A risk might be that switching from a second language to a first when students had problems with mathematics could impede development in the second language. A benefit was that students maintained their interest in learning mathematics.

An earlier Swedish study by Parszyk (1999) showed that the more diversity between students' and Swedish culture, the harder it was for students to solve word problems in Swedish mathematics national tests. As both instruction and national tests were based on western mainstream perspectives, Parszyk found that it was difficult for students to achieve good results, as their earlier experiences were not the same as the ones of Swedish students. Parszyk also gave evidence for minority students believing that school was not for them but for others; they did not feel included in the classroom discourse.

The Swedish parliament (Prop. 2005/06: 2) has set four objectives for language policy. The fourth objective is:

> Everyone is to have a right to language: to develop and learn Swedish, to develop and use their own mother tongue or national minority language and to have the opportunity to learn foreign languages.

Considering the evidence provided by Parszyk's study, the achievement of this objective seems to be jeopardized by school practices in general and school mathematics practices in particular. The issue becomes then how to conceptualize bilingualism and mathematics learning in a way that allows overcoming the simplification of attributionist, deficiency models of bilingual students.

By using a sociocultural perspective it is possible to view the languages and cultural backgrounds of the teachers and pupils as resources for teaching and learning mathematics and as a potential for the pupils' future lives (Moschkovich, 2007). When students' experiences, languages and cultural backgrounds are valued as resources, students become empowered. Skovsmose and Valero (2005) say: "It is possible to conceptualise the mathematics learner in different ways" (p. 65). Therefore, I choose to view students as individuals bringing all their linguistic, social and cultural resources to school for learning. The students' lives outside the mathematics classroom are of importance for their learning of mathematics in school as they, besides participating (or not participating) in mathematical practices in the classroom, are also members of a school, a family, a group of friends and a society. All those different arenas influence students' motivation for learning and have to be valued as resources in school.

Research methods

The *Mother tongue teaching of mathematics project* was qualitatively evaluated by me and presented in the report *Det går att lära sig mer* (Norén, 2007). The empirical data used in this article is collected and used as part of my doctoral work, to be completed in 2010.

Ethnographic methods (Hammersley & Atkinson, 2007) were used to collect data. The main data source comes from me being a participant observer, constantly taking field notes. The time of collecting data for the evaluation was due for approximately two years. I made more than 60 hours of observations in the bilingual mathematics classrooms within the project. I was observing mathematical practices, activities and the interaction in which teachers and pupils used the languages Swedish and Arabic or Swedish and Somali, for teaching and learning mathematics. A few lessons were video recorded. Furthermore I participated in the bilingual teachers' network, established by the bilingual mathematics teachers from the five schools, Swedish speaking mathematics teachers,

and two of the project coordinators. I made more formal interviews with teachers, students, school principals and official clerks. Some of them were audio taped. I transcribed both audio and video recordings. I also had informal conversations with teachers, students, and school principals. The informal conversations were in connection to the observations, before or after, focusing on lessons and often concentrating on why and how different languages were used or not. I also had to confirm many of my initial interpretations, as I speak neither Somali nor Arabic. The Arabic speaking students answered one questionnaire and five (out of eight) bilingual teachers answered another one.

I have done isolated analysis of each type of data set. In this article the sources are from classroom observations and interviews with students, teachers and school principals. The classroom observations were written in more correct Swedish out of my field notes the same day they were taken. Students' and teachers' mathematical interactions and dialogues are written down and were categorised according to how and for what purposes the different languages were used: in procedural discourses or in conceptual discourses, in referring to vernacular contexts or mathematics register contexts. To be able to analyze language use, I had to draw the boarders between different discourses in a more strict way than what I believe they really are. The mathematical discourses in the teaching were categorised according to their focus on procedural or conceptual aspects of the curriculum content. The material in the interviews and informal talks were categorised according to how students talked about their performances and sense of belonging in the mathematical practices, as including or excluding discourses. The teachers' and school principals' talks of students and their performances were categorised in the same way. The overall classroom discourses, reflected in teacher and students interactions, observed by me, were also categorised as including or excluding.

The development of mathematical discourse is a concern in Sweden, given the fact that the official curriculum demands a mathematics education that promotes a communicative and more conceptual than procedural mathematical discourse for all students. Therefore, in this paper I have chosen to focus on some results from the evaluation of the project concerning three elements impacting on the construction of mathematical discourse, namely, the mathematics curriculum and mathematical discourse, the textbooks and word problems, and the classroom discourse. These three aspects show an important achievement of the *Mother tongue teaching of mathematics project*. They point to how a change of conceptualisations of students' resources can change the mathematical practices

in school. These changes in the mathematical discourse benefit minority students' engagement in mathematical practices.

Mathematics curriculum and mathematical discourse

The Swedish mathematics school curriculum invites mathematics teachers to move teaching towards a conceptual discourse [3], including ways of communicating mathematics in classrooms and using problem solving as a basis for understanding. Nevertheless, in Swedish mathematics classrooms a procedural or calculational [4] (Cobb 1988, 2000) discourse is common as pupils often work by themselves trying to construct their own knowledge by following instructions from textbooks (Skolverket 2003, 2004). In the bilingual classrooms involved in the *Mother tongue teaching of mathematics project* a conceptual discourse was frequently found. Contrary to results in other Swedish studies where students' seem to work mostly on their own in text books (Skolverket, 2003, 2004; Johansson, 2006; Sjöberg, 2006), students in the project communicated actively, and teachers taught, instructed and guided their pupils. The bilingual teachers seemed to inspire their students and promoted mathematical learning by the creation of a rather conceptual and communicative mathematical discourse. Individual work in mathematics textbooks became less common as the project advanced. The mathematical discourse changed from a procedural to a more conceptual discourse as the communication in the classrooms increased and the dependence on the textbooks decreased. The teaching became more transparent and explicit as a consequence of the increased communication.

One explanation for this is that students participating in the *Mother tongue teaching of mathematics project* often took initiative to communicate mathematical concepts and asked questions. In interviews some of the students expressed that they felt more confident to ask questions in the bilingual teaching context than in the 'only Swedish' teaching context they had been participating in before the project started.

Boy, age 15:	It is more fun [...] I feel more at home
Girl, age 15:	I feel more secure [to ask questions]
Boy, age 16:	I didn't understand anything [...] and the [mathematics] teacher didn't understand anything, [...] Nora [the bilingual mathematics teacher] explains so I understand [...] I tried to do maths there [in the 'only Swedish' speaking classroom] [...] but I couldn't.

This change might have to do with the fact that their mother tongue was their most developed language, but also that the bilingual students were

familiar with the use of more than one language out of school, as a daily life practice. In the project they got the opportunity to do the same in school. But this change can also be a consequence of the new discourse in the school attitudes towards the use of another language than Swedish as a language of instruction in the mathematics classroom. In short, the communicative tendencies driven by the students' questions made the teaching focus more on conceptual aspects than on procedural aspects of mathematical discourses, compared to the 'only Swedish' of mathematics teaching as well as in the initial phase of the project.

During observations the students frequently asked their bilingual teachers to explain further and to give more examples on the white board to the whole group of students. They did not work much by themselves in their textbooks. Teachers often let the students take part in writing and drawing on the whiteboard and try to explain certain areas of mathematics to their fellow students. The following episode illustrates this type of practice. To the problem of how one can find the heights in different triangles and why there are three heights in a triangle, an eight-grade girl, J, started explaining in Swedish pointing to her drawings on the whiteboard. She drew three different triangles classified according to their inner angels and named them; a right triangle, an obtuse triangle and an acute-angled triangle.

T: So, where are the heights in the triangles?

J: Heights? Are there heights? This is the height in the right triangle [points to one height in the right triangle on the white board].

Another girl tells her that she can turn the triangles up side down, "then it's easy to understand that there has to be more than one height, any side can be a base". When J still hesitated, the teacher said some words naming concepts in Arabic, and gave an explanation to what a triangle *base* is in Arabic. Together, in Arabic and Swedish, the teacher and the girl, by drawing 90° angles, connected the bases in the acute-angled triangle to the heights in it.

It seemed to be possible for the bilingual teachers to promote pupils' engagement in mathematical communication by using two languages. Some teachers also stimulated meaningful discussions in mathematics by using their earlier experiences as learners themselves in their country of origin, then reflecting on the diverse traditions of mathematical instruction. For example, in introducing π, an Arabic-speaking teacher presented the students with the number 3,14 as well as with the fraction $\frac{22}{7}$ as an approximation for π. She said it was common in Iraq, her country of origin, to use both of them:

> I remember that we were used to use both the decimal approximation and the fraction for π, but mostly, I think, it was the fraction $\frac{22}{7}$. Yes I think it was on fraction as we used to call it "constant proportional value".

An interesting discussion took place among the students in ninth grade as they found different ways of looking at the constant relations between radius of a circle, circumferences and areas of circles. This discussion included the concept of constant value, "a quantity with a fixed value", "it doesn't vary [...] π is still the same [...] can I count with both?"[5]. Probably it deepened the students' conceptual understanding of these phenomena when the teacher supported the students' questions about circumference, area and π. An interesting point is that when the teacher introduced the fraction approximation an approach angle appeared for the students that they could not get just from their textbooks. In Swedish mathematical textbooks the approximation $\frac{22}{7}$ is sometimes used in historical texts about π[6].

Textbooks and word problems

The dominance of pre-produced textbooks influences Swedish mainstream mathematics teaching strongly. The textbooks also influenced the bilingual teaching in the project. The bilingual teachers had no choice but to use the books or other types of materials that are normally available in the schools participating in the project. It might indicate that Swedish mathematics teachers teaching Swedish students have implicit preferential rights of interpretation, making bilingual teachers feeling obliged to follow the traditional customs and to use the same textbooks and other materials as they do. Power relations did not seem to bee equal as Swedish mathematics teachers chose the written material the students worked with during mathematics class. This may perhaps be a sign of monolingual Swedish speaking teachers' interpretation of students' low achievement as failures within the students' personalities, backgrounds, experiences and culture rather than the teaching. These issues indicate that mathematics education for multilingual students is not only a matter of switching languages of instruction; but rather it has to deal with all the practices of mathematics education established by mainstream teachers and classrooms as part of the mainstream culture. In the project, sometimes it was not enough for the teacher just to translate word problems from Swedish into the pupils' mother tongue. Word problems in mathematics, written in Swedish, are often embedded in Swedish, or at least, western, cultural phenomena. Word problems from time to time seemed

to cause worries for pupils with cultural backgrounds other than Swedish. This is a finding corresponding to the findings of Parszyk (1999).

One example of this is when two Somali speaking boys in fifth grade tried to solve word problems. Their Somali speaking teacher translated the tasks from Swedish into Somali, but the translation did not appear to help them, especially not in the case of problems like this one, derived from the Danish writer Hans Christian Andersen's fairy tale *The princess on the pea*:

> In the fairy tale the princess on the pea had 20 mattresses. Each mattress was 10 cm. Her bed was 50 cm high. Did the princess fit on top of the bed if her bedroom was 280 cm from floor to ceiling?[7]

The two boys said that the context in the written task was not familiar to them. They got no image of what the bed would look like, as they had never heard the fairy tale. It made it difficult for them to make the arithmetic calculations even though they should not be complicated for pupils eleven years of age. The boys even had problems imagining what one mattress would look like. About the information that each mattress was 10 cm a discussion on Swedish and Somali between the teacher and one of the students, M, took place. The teacher code switched between Swedish and Somali, M spoke Swedish. The communication in Swedish went as follows:

T: Twenty mattresses [starts to draw five mattresses on top of each other on a paper in front of the boys] each mattress is ten centimetres [points to the 10 in the word problem, and translates to Somali]

The second boy, F, looks at the teacher and at M, but he does not say anything.

T: The princess on the pea [reads the word problem once again] [...] twenty mattresses [...] each one was ten centimetres.

M: Width? [...] long, length?

T: Every mattress was ten centimetres thick [draws more mattresses on top of the others mattresses, points to one, then says a few sentences in Somali]

M, seems to understand and writes $20 \cdot 10 = 200$, then looks at the word problem again.

T: 200 [...] what? [in Swedish then Somali, points to the 200 written by M]

M: Mattresses? [...] centimetres? [writes cm after 200]

The teacher goes on discussing in Somali with M. F seems not to follow. His thoughts seem to be somewhere else.

T: Her bed was fifty centimetres high [draws a bed under the mattresses and points to the space under the bed]

M: The bed [...] the bed is fifty centimetres [...] high? Twenty times ten is two hundred?

The teacher points to the mattresses and turns to F, he tries to get F involved. T draws the rest of the 20 mattresses on the bed and points to the drawing.

T: Mattress 1, mattress 2, mattress 3, [...] mattress 20.

The teachers reads the problem in Swedish again, but also using Somali. He draws the ceiling above the bed and marks the height between floor and ceiling.

T: It is 280 cm from floor to ceiling, does the princess fit on top of the bed? [points to the height]

M: 200 are the mattresses [...] then the bed, that's 50 more, [...] to [...] 250!

T: What?

M: 250 centimetres.

T: How much is left? [points to the space between the mattress on top and the ceiling] how much is it?

M: Is there space for her, [...] does she fit?

The interaction goes on a little while longer. Even though the Somali speaking teacher tried to explain in Somali as well as in Swedish, it ended up with the teacher drawing pictures representing the problem to solve, as the boys did not get an image of the problem. In the discussion on Somali and Swedish between the three of them, the boys at last solved the task.

They said there was 30 cm to go for the princess and their conclusion was she would fit, as she was thin. Along with the written task was a picture of a girl sleeping in a bed. You could see her eyes closed and her hands on top of a blanket. The bed with all the mattresses was not shown in the picture. The experiences of the boys were not taken into the choice of mathematical word problems to work with. It was a Swedish speaking mathematics teacher who had chosen the problem. The boys were not able to contextualize the mathematical task.

As a teacher, one can assume that these two Somali boys lacked experiences of having been told common Swedish or Western fairy tales, of not knowing much mathematics or of not knowing Swedish good enough to understand the word problem. Various interpretations give different answers on how to go on with the boys' education in mathematics. A

sociocultural perspective in the mathematics classroom, with a view on the these students as bilingual and second language learners with resources and experiences to learn mathematics, and an emphasis on the their participation in discourse practices could empower them, as well as enrich views on the relationship between language and learning mathematics. As Moschkovich (2007, p. 90) writes:

> [...] a sociocultural perspective shifts away from deficiency models of bilingual learners and instead focuses on describing the resources bilingual students use to communicate mathematically. Without this shift we will have a limited view of these learners and we will design instruction that neglects the competencies they bring to mathematics classrooms.

I interpreted the boys' difficulties with solving the word problem as connected to the cultural context of it. The teacher's code switching, as he said himself after the lesson observed, was about the context, not the mathematical content. In a sentence M asked "Width? ... long, length?" He knew about mathematical aspects related to similar word problems. The two boys solved other word problems in the same lesson. Some of them were more complicated to solve mathematically but had contexts familiar to the boys, like this one about sharing candy:

> Kalle and Lotta got a bowl of candy cars from their grandmother. When Kalle went out Lotta ate half the amount of the candy cars. When Kalle entered the room again Lotta was out. Then he ate half of what was left in the bowl. When Lotta came back the two children divided the rest of the candy cars between them. They got seven each. How many candy cars were there in the bowl to start with? How many had each one of them eaten when all candy cars were gone? [8]

Even though Swedish mathematics textbooks were used, examples, word problems and arithmetic methods were sometimes taken from other sources as well, sometimes from the teachers' own experiences as mathematics learners in their countries of origin. Sometimes the examples connected to other contexts more familiar to the students, than the ones in the textbooks. As an example, an Arabic speaking teacher used dates in a mathematical word problem instead of blueberries. Instead of going fishing in a boat on a lake, or swimming in the sea, a teacher talked about going to the market to buy fish and running in a field. All the changes of contexts were communicated to the students.

Taking in word problems that immigrant students may have problems to connect to a familiar context and their experiences can be looked

upon as an excluding discourse. The project opened the opportunity to challenge such exclusive discourse.

Classroom discourse

Pupils participating in the project said they felt included and secure with the ways of talking in the bilingual mathematics classroom, or, expressed in another way, in the new bilingual classroom discourse. In interviews and informal conversations pupils articulated their feelings of participation and involvement in the mathematics classroom. Many of the pupils, not recent newcomers, had earlier experiences of only Swedish mathematics teaching. Some of them expressed that it had sometimes been difficult for them to answer questions, and that it had been even harder for them to ask questions to teachers and to ask them for help in an only Swedish teaching classroom. They said the situation changed when they were able to use their mother tongue and had a bilingual mathematics teacher teaching them. They talked about feeling included and secure within the frame of the project. One pupil, representative in eight grade, said:

> It was fun with the unity when everybody spoke the same languages and [...] like that [...] you come close to each other. [...] No one was left behind or left alone. [9]

Many pupils enjoyed and appreciated to be able to talk and use their two languages when learning mathematics. If they did not know "the words" in one language, they could say it in the other language, and their teacher or a schoolmate could help them. A girl in ninth grade mentioned:

> I have learned more ... Arabic makes it easier and it makes it possible to learn more.

Another girl said:

> I learn more in this class than in the other one [only Swedish instruction].

Often students learned to communicate and use words in both languages for mathematic concepts even though the bilingual teachers often focused on the Swedish words for concepts as Swedish were used in their textbooks. This is one reason why I do not think there is a risk that the students do not develop their second language, Swedish, as Adler (2001) mentioned. The text books and other teaching materials are in Swedish, the bilingual teachers emphasise Swedish words for mathematical concepts even though they are code switching.

Swedish is the language of instruction in all other school subjects. In the future, after compulsory school, the students would probably not have the opportunity to learn mathematics in a bilingual environment. Because of that fact, the bilingual teachers found it necessary to focus the Swedish words for important concepts, for example, as in geometry *circumference*, *area*, *diameter*, and *radius*.

The bilingual teachers mostly used mother tongues for explaining while using vernacular expressions used in daily life. One example comes from a repetition lesson about how to add, subtract, multiply and divide *fractions*. One of the bilingual Arabic and Swedish-speaking teachers used the Swedish words for *numerator, denominator, lowest common denominator, shorten* and *extend*. Almost all the rest of the teaching review was in Arabic. The teacher was well aware of her code switching to focus, as she said, on the important words for the concepts in Swedish, but also to relate to the experiences pupils have in their daily life when they frequently speak their mother tongue. In the bilingual mathematics classrooms the interplay between mathematics and language often became obvious. One Somali and Swedish-speaking teacher sometimes spoke Somali while writing on the white board in Swedish. He was also well aware of his way of code switching to focus, as he said, the connection between the two languages according to mathematics concepts and to get his pupils to understand mathematics better. One girl, age 13, said in an interview that before she had not understood anything in mathematics, but "now when I have it in Somali it is a lot easier, I understand a lot".

The two teachers with earlier experiences of teaching monolingual in Swedish, then participating in the bilingual project, stated that the pupils communicated more often and asked more questions when they were able to use both languages, in the same way as they often do between friends when not in class, and within their families.

It seemed as though the bilingual teachers, as one could expect, considered students first languages as resources for constructing mathematical knowledge and communicating mathematically, even though not all of them did when the project started up in 2004. In 2006 one of the bilingual teachers said:

> In the beginning I hesitated to use my mother tongue [...] now I see a lot of advantages [...] but I don't know if I dare to use it if I wasn't in the project [...] if it wasn't a project I might not do it [...] within the frames of the project it is okay [...] even though I see the advantages [...] and how much the students learn. Other teachers in the school don't think it is okay.

The other bilingual teachers expressed similar opinions about the discourse change. Also some of the students' with experiences of 'only Swedish' mathematics instruction hesitated to use their mother tongue in mathematics class at the beginning of the project. A student in ninth grade said at the end of the project:

> The teachers decided who should be in the bilingual mathematics class or not. I felt set apart. Now it is good that I could participate. I would tell my younger sisters and brothers to go. If the teachers hadn't decided I wouldn't know what it could give me.

The statements reflect the school practices in general and the discourse 'Swedish only' as dominant in Swedish school contexts. In the schools participating in the project the discourse changed to include the mother tongues of the students and teachers as resources for teaching and learning mathematics. With the change of discourse students, particularly the newcomers, got access to a language of instruction and were able to communicate mathematically (Adler, 2001). The new discourse included the mother tongue languages as resources for teaching and learning mathematics (Moschkovich, 2007). In that sense the new classroom discourse is inclusive and probably more empowering than the 'Swedish only' discourse.

As the teachers had immigrant backgrounds themselves, most of their own education was taken at their countries of origin. However, they had also had educational experiences in Sweden. They themselves had experienced what it means to learn in a language not one's own first language and, therefore, they had developed an awareness of how complex the situation can be. As the teachers had the same language and a similar cultural background as their pupils, they were able to draw on their own and the students' earlier experiences, and to use code-switching as tools for teaching and learning mathematics. The teachers or the students could have said the same as Setati expressed in a dialogue with Barwell (Barwell & Setati, 2005), by saying "Whenever I bump into some mathematics that does not make sense to me I draw on my social, cultural and linguistic resources to make sense of it" (p. 22).

At the beginning of the project, there were doubts raised from different directions and persons involved. One example comes from a headmaster, in one of the five project participating schools. He pointed to an important fact. He had objections to the idea of the project and his main concern was that he was not sure that the mother tongue mathematics teaching project would benefit the pupils' learning of Swedish (he saw the same risk as Adler mentioned). At the end of the project he

expressed that when he realised pupils "could get grades in mathematics without knowing much Swedish", all anxieties disappeared. He said that he had realised that pupils' ability to show and expand their knowledge in mathematics strengthened them and made them proud of themselves. That influenced the whole situation for the better, particularly for the newly arrived pupils in school, he said. Another headmaster referring to the experiences in the project of her students getting good results in mathematics and the change of discourse said:

> In the start we knew so little [...] the network was new, the Swedish-speaking teachers didn't prioritise this work [...] we should have understood this earlier [...] The students arrive from different countries, and what do they bring with them? At least they bring another language than Swedish.

Concluding remarks

The answer to the question "how do mathematical practises emerge in bilingual mathematics classrooms?" is complex. One answer out of the evaluation of the project is that the bilingual mathematics teachings made the teachers teach more transparently and explicitly. Communicative and more conceptual discourses of instruction became apparent as the project found its forms. One more answer is that bilingual students can benefit from bilingual teaching of mathematics not just because of the use of their two languages in the classroom, but also because of the changed attitudes towards their mother tongue as a resource for learning mathematics.

The students who seemed to achieve most within the project were recent newcomers to Sweden, age 14–15. They would reach the final classes in Swedish compulsory school within a year or two after their arrival. If they had not been in the bilingual teaching mathematics project they would have had all their instruction in Swedish, in a preparation group, struggling learning basic conversational fluency, and probably not getting the same chance to communicate mathematically and to progress mathematically.

For a second language learner it is difficult to use communication skills and achieve cognitive creativity to solve problems, at the same level as a first language learner, as he/she has not yet reached the same level or stage in Swedish language development – when Swedish is the language of instruction. There will be a language barrier for learning in general. In bilingual mathematics teaching the bilingual students get access to different languages of instruction. As a consequence, the language barrier

falls and the students learn in their first language as well as in their second language. This observation in fact resonates with research findings in other places in the word, such as Boaler (2007) where successful schools actually manage to make a difference for bilingual students.

My interpretation of students' sense of inclusion in the bilingual teaching mathematics classrooms in the project is opposite to Parszyk's (1999) findings that school for the minority students in her study was not experienced to be a school for them, but for the others – the Swedish students. The students in the bilingual teaching of mathematics project felt that school, at least mathematics education, was for them. A change from an excluding discourse, 'only Swedish', to an inclusive discourse where students linguistic and cultural backgrounds are valued as resources for teaching and learning mathematics is fundamental.

Minority students' access to study mathematics is of great importance and seems to increase while they have possibilities to use their first language as a language for learning mathematics alongside Swedish. Teachers have to depend on what pupils bring with them into the mathematics classroom and to what their earlier experiences are. The bilingual teachers participating in the project considered students' first languages and cultural backgrounds as resources for constructing mathematical knowledge. Some of them considered perspectives according to their own, as in the above mentioned example of π, or to students' earlier experiences, Some of them saw also the students' lives and their environments of today, as resources for developing mathematics concepts.

Teaching is a cultural activity (Stigler & Hiebert, 1999) signifying that teaching is learned through participation over long periods of time. For example, in Swedish mathematics classrooms, it is often more customary to concentrate on decimal numbers than on fractions. In some other countries, Somalia for instance, it is more common to work a lot on fractions. Apparently the bilingual teachers participating in the project had engaged in different ways in a power struggle with the only Swedish-speaking teachers: Who was the right one to choose materials and content to work with in the mathematics classrooms? A move towards a comparison of differences in the teaching of diverse contents could have been an area of cooperation connecting the bilingual and the Swedish speaking mathematics teachers.

When pupils, through their mother tongue get access to mathematics discourse, which has a high amount of symbolic capital (Bourdieu, 1991) in Swedish society at large, it seems as though the status of students' first languages also gets enhanced. Symbolic capital is added to the mother tongue. "My language is good enough for learning mathematics" is a thought expressed in some of the pupils' and bilingual

teachers' ways of speaking about mathematics and language. Some pupils seemed to develop a deeper interest in mathematics and also got better results in tests.

As Sjögren (1997, p. 7) wrote:

> In Sweden the principle of home-language[10] teaching as a way to provide students with an academically sound bilingualism has been accepted for more than twenty years, but still has great difficulties in becoming incorporated as a basic element into the school curriculum.

Since 1997 the view on pupils' home languages or mother tongues has changed. There has also been a shift in official policy on which language to use for instruction in mathematics. The *Mother tongue teaching of mathematics project* is a result of the change of attitudes towards bilingual or/and mother tongue instruction. Despite the positive results shown by this project, there are still hesitations among teachers, politicians and administrators. Sjögren (2002, p. 16) says:

> It's not so much Swedes themselves who are 'Swedish', but institutions – the Swedish schools, parliament, police, press, and so on. And being institutions, they are extremely slow to change. They support the existing ideology and way of thinking.

There seems to be a lot to gain for bilingual students in mathematics classrooms when bilingual teachers' and students' first languages are used for teaching and learning mathematics. To be able to communicate in a mathematical learning situation, students need to use their language(s) of thinking and their cultural and social backgrounds as tools for mediation, in order to be able to develop new concepts and ways of understanding. It can mean a lot to students' confidence in themselves to be "good at" mathematics in school, in a country such as Sweden.

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Notes

1 In Swedish official terms, mother tongue is a persons first language used and learned at home.

2 International OECD studies concerning students results in school.

3 Reasons for calculating in particular ways are discussed.

4 Mathematics has its own mode of discourse and register, to "talk mathematics" involves calculational or procedural ways how to "do" mathematics, focusing on rules and procedures; how to calculate.

5 Two different students' expressions.

6 Though this form was not present in the textbook that was in use.

7 My translation, the text is formulated by Forsbäck & Olsson (2003) in Swedish.

8 C*andy cars* is a famous Swedish candy that it is possible to buy in any store in Sweden. The word problem was created by Forsbäck & Olsson 2003.

9 Translations by me.

10 Before 1997 the word home-language was used, after 1997 the word mother-tongue is used for the same phenomenon.

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Sammanfattning

Artikeln presenterar några av resultaten från ett tvåspråkigt matematikundervisningsprojekt, vilket bedrevs i fem mångkulturella skolor i Sverige. Den övergripande forskningsfrågan var: Hur utformas matematikpraktiker i tvåspråkiga matematikklassrum? Genom möjligheten att använda två språk verkade elevernas engagemang i klassrummet öka. Därigenom stärktes deras potential att lära matematik.

Elever och lärare kommunicerade matematik på olika sätt, och samverkan mellan matematik och språk blev ofta uppenbar. Tvåspråkiga elever som deltog i projektet uttryckte att de hade möjlighet att lära sig mer, och de kände sig mer säkra, när de kunde använda båda sina språk på matematiklektionerna. Genom att delta i projektet ökade många elevers tilltro till sin egen förmåga i matematik.