

**Mathematics teaching and learning of immigrant students:  
A look at the key themes from recent research: <sup>1</sup>**

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*Several themes emerge from the review on the mathematics teaching and learning of immigrant students. The theme of different forms of mathematics is quite prominent in research with immigrant students. Researchers strongly suggest the need for teachers and schools to look at the different kinds of mathematics that immigrant students are likely to bring with them and to use this knowledge as a resource for learning. Research points to a deficit view on the part of teachers (not all teachers, though!), schools and the public in general, towards immigrant students and their families. The public discourse that tends to portray immigration as a problem rather than as a resource makes its way into the schools. As a result, the focus is on what immigrant students cannot do or do not know, which in most cases centers on their not knowing the language of instruction. Little research documents experiences that center on diversity and multiculturalism as a resource for learning. There is a clear need for teachers to gain a better understanding of their immigrant students' and their families' knowledge and experiences. The emphasis on language as "the problem" is promoting approaches that segregate immigrant students and bring to question issues of equity in the mathematics (and other subjects) education they are receiving. Research with immigrant parents across different countries brings up several themes in common, including: a concern on the part of immigrant parents for a lack of emphasis on the "basics" in the receiving country; a perception that the level of mathematics teaching was higher in their country of origin; and a feeling that schools are less strict in their "new" country. Most of the research reviewed falls within the sociocultural framework, with several studies taking a sociopolitical approach. Issues for further research are also addressed in this review.*

### **Introduction**

Currently, the mathematics teaching and learning of immigrant students is of utmost importance. As Gates (2006) writes,

In many parts of the world, teachers—mathematics teachers—are facing the challenges of teaching in multiethnic and multilingual classrooms containing, immigrant, indigenous, migrant, and refugee children, and if research is to be useful it has to address and help us understand such challenges (p. 391).

The purpose of this paper is to highlight the main findings, advances, challenges, and indicate topics for further research in the area of mathematics teaching and learning of immigrant students. In the last few years there seems to have been an increase in attention to issues related to the main topic of our survey team—mathematics education in multicultural and multilingual environments. For my specific topic, the mathematics teaching and learning of immigrant students, I focused primarily on proceedings of recent

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<sup>1</sup> This is a shorter version of the original paper written for this purpose (Civil, 2008a).

international conferences that I know have presentations related this area. Much of this work is actually centered on research in Europe. Then I went through the information received from various researchers who responded to our team's call for contributions. Some of these researchers sent a summary of their most relevant work; others addressed the following two questions (suggested by our team's chair, Alan Bishop):

- A. How do you think the situation has changed/improved/deteriorated etc. in your research/development work in the last few years?
- B. What problems/challenges do you see in the next few years?

Finally, I focused on aspects of research in the mathematics education of Latino/a students in the U.S. These three sections (proceedings, contributions, and research with Latino/a students) are discussed at length in the longer version of this paper (Civil, 2008a). Here I focus on the main themes that I extracted from going through all these sources. Although I have organized this paper in themes, I want to point out that there is a lot of overlap across the different themes.

### **Different forms of mathematics**

Several studies address issues related to everyday mathematics, critical mathematics, community mathematics, school mathematics, and so on. For example, researchers in Greece have been looking at Gypsy / Romany students' use of mathematics in everyday contexts, in particular computation grounded on children's experiences with their involvement in their families' business (Chronaki, 2003; 2005; in press; Stathopoulou and Kalabasis, 2002; 2007) (Moreira (2007) reports on a study along the same topic but with Portuguese Gypsy children). Some aspects of this research remind us of the work with street vendors in Brazil described in Nunes, Schliemann, and Carraher (1993). However, particularly relevant to our theme is the observation by the researchers in Greece that schools and teachers seem to show little interest in what knowledge minority students (in this case Gypsy) bring with them and thus, in how to build on this knowledge for classroom teaching. It may be little interest on the part of the teachers, or it may be due to an unawareness on how to build on this knowledge. Stathopoulou and Kalabasis (2007) argue for the need for schools to recognize and build on the oral tradition and experiences with mental arithmetic that Romany children have from their participation in their community's everyday activities. Chronaki's (2003; 2005; in press) research with Greek Roma children uses the concepts of learning identities and that of Roma funds of knowledge<sup>2</sup> as resources for instruction to gain a better understanding of Gypsy children as mathematical learners

The topic of bridging in-school mathematics and out-of-school mathematics has received quite a deal of attention in research in the recent years (e.g., Abreu, Bishop, & Presmeg, 2002; Civil, 2002c; 2007; Nasir, Hand, & Taylor, 2008; Presmeg, 2007). My work and that of my colleagues building on the concept of Funds of Knowledge provide important insights into the development of modules and teaching approaches in mathematics that

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<sup>2</sup> The concept of funds of knowledge refers to the knowledge and experiences that exist in any household (González, Moll, & Amanti, 2005).

build on students' and families' knowledge and experiences. The pedagogical transformation of the findings from the household visits into mathematical learning modules for the classroom is quite challenging (Civil, 2007; Civil & Andrade, 2002; González, Andrade, Civil, & Moll, 2001). Some of these challenges have to do with time, support, and most relevant to this discussion, the notion of what counts as mathematics. Many of the questions on this topic that I raised at ICME 8 (Civil, 1996) are still relevant today, I believe. Two of those questions were: "Can we develop learning experiences that tap on students' areas of expertise and at the same time help them advance in their learning of mathematics?" and "What are the implications of critical pedagogy for the mathematics education of 'minority' and poor students?" It is worth noting that more recently there seems to be quite a deal of research activity in the general topic of critical mathematics and teaching mathematics for social justice (Bartell, 2005; Díez-Palomar, Simic, & Varley, 2007; Gutstein, 2003; 2006; 2008; Turner & Varley, 2008). While my work focused mostly on connecting classical and community knowledge, the work of many of these researchers has been looking at connecting classical and critical knowledge, and in some cases, the three forms of knowledge (Gutstein, 2006; 2008). Powell and Brantlinger (2008) discuss some of the tensions around their own work with Critical Mathematics, tensions such as "the critical and mathematical goals of the activity" (p. 431), or students' reactions and resistance to critical mathematics. Powell and Brantlinger distinguish between two approaches to Critical Mathematics (CM), one more focused on issues of access to academic mathematics (CM1) and the other more focused on political aspects (CM2). In their conclusion, they raise important questions that should be of relevance to our work with immigrant students, such as,

What messages (e.g., about the nature of mathematics, mathematics learning, marginalized students, and their communities) are being sent to students in CM1 and CM2 activities? What language or discursive registers (students' vernacular, academic mathematics) or modalities (iconic, indexical, symbolic) are privileged in different versions of CM...? (p. 432)

To me, what is of particular interest, probably because it resonates with what I wrote years ago (Civil, 1996) but also in my current work with graduate students in CEMELA (Center for the Mathematics Education of Latinos/as)<sup>3</sup>, is what Powell and Brantlinger (2008) write:

It is important that critical mathematics educators create narratives that are alternative to the idea that mathematics is inaccessible and the misconceptions about its inherent nature and about who can do mathematics. CM educators should not be satisfied with engaging historically marginalized students in politicized investigations of injustices (e.g., wage distributions) if they do not have access to academic mathematics. (p. 432)

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<sup>3</sup> CEMELA is a Center for Learning and Teaching (CLT) funded by the National Science Foundation under grant ESI-0424983. The views expressed here are those of the author and do not necessarily reflect the views of the funding agency.

As we consider different forms of mathematics and whose mathematics to bring to the foreground, issues of power and valorization of knowledge become prominent. Abreu has written extensively on the concept of valorization of knowledge (Abreu, 1995; Abreu & Cline, 2007). Another body of research that is relevant here is actually that of mathematics education and indigenous students. Meany (2004) writes about issues of power and whose knowledge gets recognized in the context of her work within a Māori community. Zevenbergen (2008) brings up several dilemmas in relation to the mathematics education of indigenous students, which seem relevant to the education of immigrant students:

How relevant are particular forms of knowing mathematics, what forms or aspects of the mathematics curriculum are needed or should be included in curriculum for the students or should the expectation be one where they are exposed to the same curriculum as their urban counterparts. (p. 5)

Finally, the work of Lipka in Alaska on developing a mathematics curriculum that integrates school mathematics with traditional Yup'ik practices (Lipka, Webster, & Yanez, 2005) is an example of linking community and classical school mathematics. It seems that there is much that we could learn for the mathematics teaching and learning of immigrant students from the ethnomathematics projects that develop curriculum and teaching approaches with indigenous communities.

### **Teacher education**

Much of the research I reviewed for this topic addressed teachers' attitudes and knowledge of immigrant students. This body of research presents a rather grim picture and thus opens the door to several possibilities for further research. Reports on an European project that is looking at the teaching of mathematics in multicultural contexts in three countries, Italy, Portugal and Spain, point out that teachers feel unprepared to work with immigrant students (Favilli & Tintori, 2002). César and Favilli (2005) report that teachers in this study underscore the issue of language as being a problem and do not seem to recognize the potential for richer learning grounded in different problem solving approaches and experiences that immigrant students may bring with them. They also note that teachers seem to have different perceptions on immigrant students based on their country of origin. Overall, my reading of these reports points to a deficit view by teachers of their immigrant students.

Abreu (2005) reports that most teachers in the studies she examined tended to “play down cultural differences” arguing for general notions of ability and equity, as in treating everybody the same. Gorgorió (personal communication, April 28, 2008) also mentions that “teachers tended to make invisible the cultural conflict that would arise in their classrooms as a result of the discontinuities between different school cultures and different classroom cultures.” Abreu points out the need for teacher preparation programs to pay more attention to the cultural nature of learning.

Gorgorió and Planas (2005b) discuss the role of social representations in teachers' images and expectations towards different students. In particular, they write, “unfortunately, too

often, ‘students’ individual possibilities’ do not refer to a cognitive reality but to a social construction. Teachers construct each student’s possibilities on the basis of certain social representations established by the macro-context” (p. 1180). The influence of the macro-context, and more specifically the public discourse around immigration as being a source of problems rather than a resource for learning is a common theme in this review. Researchers are critical of this discourse (e.g., Alrø, Skovsmose, and Valero, 2005) as it is counter-productive to the education of immigrant children. Unfortunately, as Gorgorió and Planas (2005b) point out, some teachers use this public perception as their orientation to assess immigrant students in their classrooms, rather than a direct knowledge and understanding of their individual students and families.

This need for teachers to gain a better understanding of their students and families is addressed in the work of Civil and colleagues. This work points to the potential of teachers engaging in action research in multicultural contexts in terms of teachers developing curriculum and approaches that build on students’ knowledge and experiences (Civil, 2002b; 2007; Civil & Andrade, 2002; Kahn & Civil, 2001; Planas & Civil, 2007). Civil and Andrade (2002) describe the impact of ethnographic household visits on teachers’ views of their students. Teachers gain an understanding of their students’ context; they also learn about the different activities, networks, and resources that their students and families draw on. This may be a promising direction for teachers to learn first-hand about their students’ contexts, instead of relying on public discourse about them. Civil and Bernier (2006) highlight some of the challenges in having teachers and parents (Latino/a parents in their study) work together to present mathematics workshops to the school community. Issues of power and of whose knowledge is valued are very present. Quintos, Bratton, and Civil (2005) bring up the need for parents and teachers to value the different approaches to doing mathematics that are likely to be present in multicultural settings. They point out that often teachers do not recognize parents’/ home approaches as a valuable mathematical contribution.

There is a clear need for teachers to understand other ways of doing and representing mathematics (Abreu & Gorgorió, 2007; Civil & Planas, 2008; Moreira, 2007). As Abreu and Gorgorió (2007) write in relation to a teacher’s reaction to differences between representations of division in Ecuador and in Spain, “the relevant question is not whether there are any differences in the representation of the algorithm of the division, but how teachers react to the differences” (p. 1564). Related to the need for teachers to know about others’ ways of doing mathematics, is a need for an expanded view of what mathematics is. Teachers tend to view mathematics knowledge as culture-free and universal (Abreu & Gorgorió, 2007; César & Favilli, 2005). This point relates directly to the previous section where I discuss different forms of mathematics. It seems that teacher preparation programs and professional development experiences should address this view of mathematics as being culture-free. Moreira (2007) brings up the need for teacher education programs to prepare teachers to research this locality of mathematics (e.g. everyday uses of mathematics). In referring to the mental computation strategies used by Portuguese Gypsy children, Moreira writes,

If teachers are not aware of children's mental calculation processes and do not use them to know more about the role of local mathematics in mathematical knowledge in contemporary society, a good opportunity to educate the citizens of the world is lost. (p. 1594)

Furthermore, by seeing mathematics in this universal and culture-free way, teachers tend to believe that the only issue that immigrant students have when learning mathematics is learning the language of instruction (Abreu & Gorgorió, 2007). I will come back to the topic of language later in this review, but here I want to point out the work of Khisty and Chval, in which they illustrate teachers' effective use of the home language as a resource for the teaching and learning of mathematics (Khisty, 2006; Khisty & Chval, 2002).

### **Issues related to educational policy**

Researchers from different countries are critical of educational policies that push towards assimilation of immigrant students. These policies convey a deficit view on immigrants' language and culture, instead of promoting diversity as a resource for learning.

Anastasiadou (2008) writes,

The de facto multiculturalism (...) which now describes the Greek society, ... [which] continues to function with the logic of assimilation (...). In the field of education the adoption of the policy of assimilation means that it continues to have a monolingual and monocultural approach in order that every pupil is helped to acquire competence in the dominant language and the dominant culture. (p. 2)

Similarly, Stathopoulou and Kalabasis (2002) point to how the curriculum "takes into consideration only the needs and backgrounds of the children of the dominant group ... [and] does not care about what students of other groups, especially minority groups, bring into the classroom" (p. 8). The work of Alrø et al. (2005) is particularly relevant here as these authors take a socio-political approach to the discussion of the teaching and learning of mathematics with immigrant students. The influence of public discourse and in particular of the view of immigration as a problem rather than a resource is well captured in what these authors write:

In Denmark, the sameness discourse has spread into a variety of discourses, which highlight that diversity causes problems – it is not seen as a resource for learning. And this idea brings about a well-defined strategy: Diversity has to be eliminated. (p. 1147)

Then, as researchers in other parts of the world have noted, these authors point to the emphasis in educational policy on students' acquisition of the Danish language as the priority. Alrø, Skovsmose, and Valero (2007) argue for the need to look at the complexity of the situation, rather than at just one aspect (e.g., language). In their study with 8<sup>th</sup> graders at a school with a considerable number of immigrant students, the authors note that students did not seem to pay much attention to the topic of multicultural diversity: "diversity is not used as any resource for teaching and learning" (p. 1571) These researchers write,

The students are well aware of cultural differences, but they seem to agree that to take specific notice is not important.... This indicates that they represent the 'sameness' approach in the Danish public discourse about integration, which implies making 'them' just like 'us'. (p. 1571)

The idea that mathematics education is political is particularly true when studying the mathematics education of immigrant students (see Valero, 2007, for a discussion of theoretical tools to understand mathematics education from a socio-political stance). An implication from the research that looks at the macro-context, and in particular the influence of public discourse and educational policy on the education of immigrant students, is the need for interdisciplinary research teams, where in addition to the expected expertise in mathematics education, there is expertise on the political and policy (social, educational, language, in particular with respect to immigrant students) scene in the context (country, region) of research.

### **Language, mathematics, and immigrant students**

It is not my intention to summarize here the research related to language and mathematics in multilingual settings but I do include some contributions I received on this topic and then focus on issues of language policy and the mathematics teaching and learning of immigrant students.

Richard Barwell (University of Ottawa, Canada) writes,

Thinking specifically about multilingual issues in mathematics education, there is perhaps a modest increase in attention to the topic, although given the general increase in research in education generally, this increase appears to be even more modest. I think multilingual issues do have a slightly higher profile as a topic of research, if you will.

(...)

There is another dimension, however, in which I see little change - that is the broader acknowledgment of multilingual issues (and multicultural issues) in research in mathematics education more generally. That is to say, most classrooms these days can be described as multilingual and/or multicultural in some way and, for me, this potentially has major implications for doing research - the methods we use, the theories we use, and the way we interpret and analyse our data. It concerns me how rarely researchers mention whether the participants involved in their studies are working in their main language, for example, or in an additional language. (R. Barwell, personal communication, May 10, 2008)

For some recent publications by Richard Barwell see, Barwell, 2005; in press; Barwell and Clarkson, 2004; Barwell and Kaiser, 2005; Barwell, Setati, and Barton, 2007.

Phillip Clarkson (Australian Catholic University, Australia) writes about what seems to be a widespread approach in the teaching of mathematics to immigrant students, that is the use of the official language(s) of instruction at the expense of the home language of many of these students:

Much of this research was also blinkered by the power of the dominant societal values that pervade classrooms (Clarkson, 2006b). Mathematics teaching, like all the teaching that occurs in a school, normally is mandated to be carried out in the dominant language of the society. The use of other languages is normally proscribed. For immigrant children this may be an important matter. If they are from homes that speak a language different to the dominant societal language, then much of their formative early learning undertaken before schooling has begun will be encoded in their home language. And much of this will be in the verbal domain of that language. Hence for schools to take no or little notice of these extra hurdles that such students have to leap is to simply not be realistic. Incidentally it is not just immigrant children that may face such obstacles. Children beginning school in the hill country of Vietnam or from most places in Papua New Guinea will not have the official language of teaching as their home or first language. Hence this issue is broader but contextualised differently for many different groups of school children throughout the world (Clarkson, 2004). It is also a question that impinges on the ongoing concern for sustainable education, the importance of which has been an issue for UNESCO (Clarkson, 2007a).

(...)

Vietnamese and Iranian migrant students in Australia have been shown to use their first languages when they are working with mathematical ideas, although their teachers are normally unaware that their students are switching languages as one of their solution strategies (Clarkson, 2006a; Parvanehnezhad & Clarkson, in press). The same may well be true of most Malaysian students, who since the beginning of 2005 are now learning mathematics in English, rather than the most common language in the country, Bahasa Melayu (Clarkson, & Indris, 2006). In Australia, some thought is now being given to the teaching implications for multi lingual classrooms. Unlike some classroom contexts where the teaching of bilingual students has just the home language of the students and the official teaching language as mediums of communication, in many Australian urban classrooms there may well be 10 different languages represented. Such is the language mix of students in Australian cities. This context is in stark contrast to the assumed context that is made by the mathematics curriculum documents; all teaching will be in English and indeed this is the only language that needs to be considered (Clarkson, 2005). A long held model that has been advocated in the literature and curriculum documents, that is the language of mathematics is best taught by starting with students' informal language and gradually moving to the precision of mathematical language, has been critiqued. It has been shown that this model has been developed in the context of monolingual teaching contexts. If the real contexts for bilinguals learning mathematics is to be taken, then this model needs to be elaborated so the multiple languages within a classroom are not only recognised but are incorporated into the model as appropriate pathways for learning. Then this teaching model will start to reflect what we know about how students actually go about their learning (Clarkson 2007b, in press). (P. Clarkson, personal communication, May 25, 2008).

Susan Staats (University of Minnesota, USA) brings another dimension of the language as she reflects on one of the trends in mathematics education that argues that using students' home language can help them in their learning of mathematics. She wonders what happens when students do not really know their home language, as is the case of the Somali students with whom she works. She writes,

With the educational history of Somalis they do not know their math vocabulary. It is a point of sadness, in fact, for many young people that they feel they do not know any language well, they might know parts of Somali, Swahili, Arabic, Italian, or English but feel insecure speaking any of these. (S. Staats, personal communication, June 8, 2008)

She describes her current project in which Somali undergraduate and high school students are learning algebra while learning mathematics vocabulary in Somali and in this way connecting these young people to their history and culture. She then raises the issue of what to do when teachers and students do not share the language, as is the case in many multilingual classrooms:

Given that we believe speaking math helps students learn, what can a teacher do to engage this power of language if she does not share the language? How can a teacher--or a multilingual community--be pro-active with little time and a low budget? This is a common situation in the US, and there are so many languages involved, we cannot wait for multilingual materials to be published. So I wondered if online videos--with low-budget production values!--produced through teacher/community partnership, could be a model for other languages. (S. Staats, personal communication, June 8, 2008)

Ed Elbers (Utrecht University, The Netherlands) reports on two studies that among other goals are looking at issues of collaboration, interaction, discussion in multicultural mathematics classrooms, hence looking at issues of language and mathematics in these classrooms (Elbers & de Haan, 2004; 2005; Elbers, Hajer, Jonkers, & Prenger, 2005; de Haan & Elbers, 2004; 2005 a; b; c; 2008). Elbers also discusses in his personal communication the situation with mathematics education in the Netherlands. His comments are very telling and relate both to the prior section on issues related to educational policy and to this section on language:

Realistic Mathematics was also criticized as being not real math (also by leading mathematicians in the Netherlands), and being based more on semantics and interpretation of assignments than on math knowledge and skills. They claim that the Dutch good achievement in math in the PISA studies is because the PISA studies do not test real math. Many plead for a return to transmission of knowledge in classrooms. The bad results of minority children in schools, in the recent debate, was partly explained with a reference to educational methods such as students learning by collaboration and investigation. These methods, the argument runs, depend on students' skills in Dutch and therefore these students, because of their language gap, can never be successful in math. (E. Elbers, personal communication, May 14, 2008)

As we can see, once again, language is singled out as the obstacle to immigrants' learning of mathematics. Elbers' comment is even more pointed as it is focusing on a critique of discussion-rich approaches to teaching mathematics that could be problematic for students for whom Dutch is not their first language. Moschkovich (1999; 2007a; b) addresses this topic in her research with English Language Learners in the U.S. She writes,

The increased emphasis on mathematical communication in reform classrooms could result in several scenarios. On the one hand, this emphasis could create additional obstacles for bilingual learners. On the other hand, it might provide additional opportunities for bilingual learners to flourish. (Moschkovich, 2007b, p. 90).

She then argues for a sociocultural perspective that moves away from what bilingual learners cannot do and,

Instead focuses on describing the resources bilingual students use to communicate mathematically. (...). If all we see are students who don't speak English, mispronounce words, or don't know vocabulary, instruction will focus on these deficiencies. If, instead, we learn to recognize the mathematical ideas these students express in spite of their accents, code switching, or missing vocabulary, then instruction can build on students' competencies and resources. (Moschkovich, 2007a, p. 90)

Núria Gorgorió (Universitat Autònoma of Barcelona) reflects on her research trajectory. In this reflection, Gorgorió seems to imply the power issues associated with language

During this initial time we were looking at the multicultural classroom from the perspective of it being multilingual (Gorgorió & Planas, 2001), when it became clear to us that we should not regard language only as a vehicle in the construction of mathematical knowledge, but also as a social tool in the process of sharing meanings within the mathematics classroom. (N. Gorgorió, personal communication, April 28, 2008)

As we have seen, in the eyes of education policy-makers and many teachers, not knowing the language of instruction is seen as a major (and in most cases the main) obstacle to the teaching and learning of mathematics of immigrant students. Hence, the push is for these students to learn the language(s) of instruction as quickly as possible. As Alrø et al. (2005) point out, the emphasis on learning the language of the receiving country may occur at the expense of these students' learning of mathematics. Gorgorió and Planas (2001) have documented a similar situation in Catalonia. In fact, at the moment, there is ongoing debate in Catalonia around the proposed education policy for immigrant students that would keep them in separate school buildings apart from the local students (or from those who already know the language of instruction) with the aim that they learn the language of instruction. I was first made aware of this proposed policy in January 2008. I recently asked Núria Planas (Universitat Autònoma of Barcelona) for an update. She writes,

There are still “reception classrooms” though we are in a transition time and the length of stay in these classrooms varies from half a year to one year. Right now these reception classrooms are in regular schools, but the talk is about creating separate spaces [different buildings], thus increasing the segregation of immigrant students. It is very controversial and it is not clear that they will be able to do it. (N. Planas, personal communication, May 22, 2008)

Gorgorió comments on how changes on educational policy have directly impacted their program of research:

The empirical context has also evolved out of our control: initially we were studying the processes that were taking place in mainstream classrooms that immigrant students attended; now we have included in our empirical domain the ‘reception class’ since it is a new scenario set up by the educational administration to address recently arrived students who do not master Catalan, the language of instruction in Catalan schools. (N. Gorgorió, personal communication, April 28, 2008).

For some recent publications from Núria Gorgorió and Núria Planas see: Gorgorió and Planas, 2005a; b; c; d; Gorgorió, Planas, and Bishop, 2004; Gorgorió and Prat (in press).

In my local context (the U.S.) there is long history of changes in language policy for education, with some states now having banned or severely limited bilingual education, including the one I am in, Arizona. In Civil (2008b) I briefly describe the change in language policy in Arizona and write,

The [new] law allows teachers to use a minimal amount of the child’s native language for clarification, but “all children in Arizona public schools shall be taught English by being taught in English and all children shall be placed in English language classrooms” (ARS, 15-752). The impact of this change has to be seen within the larger political scene in which there is currently a big debate on immigration reform at the national level. In our local context, feelings of anti-immigration and racism seem to be particularly intense with the passing of different laws on immigration issues. (p. 2)

In Civil (2008b) I illustrate some of the implications of this law, by focusing on one student who was Spanish-dominant and had a good command of mathematics (she had learned much of what she was being currently taught in her previous school in Mexico). I raise questions about equity and the opportunities for participation and further learning of mathematics for this student.

The most recent proposal in Arizona, to be implemented this coming school year, pushes this law even further by separating the students classified as English Language Learners (ELLs) for 4 hours a day to focus on their learning of the English language. This will be done at the expense of their learning other subjects and of being immersed with English speaking peers who could serve as supports for their learning of this language. Needless to say that this law is creating a huge amount of controversy. Local districts are proposing

alternatives to the 4-hour mandate and at the time of this writing are waiting to hear if they will be approved. Just recently one small school district near Tucson announced that they were not going to follow this law at the middle and high school level (they would at the elementary school level, though the plan is to integrate the teaching of English throughout the regular day). As the newspaper reporter writes,

The (...) district faces a question that every public school in Arizona must answer: Will English-language learners get an equal education if they're forced to spend four hours a day in a language class? (Arizona Daily Star, May 24, 2008)

One of the school district's officials checked with the Office of Civil Rights at the federal level and followed their conclusion, which was not to follow the law. This district official says (in the same newspaper article), "it is discriminatory, especially at high schools, where you prevent students from taking the same number of classes, preventing them from graduating in four years."

There is another side to issues of language policy and mathematics education of immigrant students that seems to have been less researched: immigrant parents' views on this issue. This topic of research is quite prominent in our Center CEMELA (Center for the Mathematics Education of Latinos/as). For example, in Acosta-Irqui, Civil, Díez-Palomar, Marshall, & Quintos-Alonso (2008), we look at two CEMELA sites (Arizona and New Mexico) that have different language policies (in Arizona, bilingual education is extremely restricted, while in New Mexico it is endorsed in their state constitution). This allows us to contrast the effect of such different language policies on parents' participation in their children's mathematics education. An interesting theme emerging from our research with immigrant parents is that for many of them language also seems to be the main obstacle to their children's learning of mathematics (this parallels what teachers think as we have illustrated earlier). This is the case in our research with mostly Mexican parents (Civil, 2006; in press; Civil, Díez-Palomar, Menéndez-Gómez, Acosta-Irqui, 2008) but is also the case with immigrant parents in Barcelona (Civil, Planas, & Quintos, 2005). The reason why I think this is an important topic to pursue is because as immigrant parents focus on the language as being the main obstacle, we wonder whether they are aware of the actual mathematics education that their children are receiving. In particular, I am referring to issues of placement: are the students placed in the appropriate mathematics classroom (based on their knowledge and understanding) or are schools basing their placement on their level of proficiency in the language of instruction? In Civil (2006; in press) I present the case of Emilia, a mother who seems satisfied with the fact that her son is mostly "learning" content that he already knew from Mexico because, as she says:

That is, for them it's perfect what they are teaching them because in this way it's going to help them grasp it, to get to the level, because for them, with the lack in English that they have, and if to that we were to add, ... Right now, what he is learning, what I see is that it's things that he had already seen, but if he gets stuck, it's because of the language, but he doesn't get stuck because of lack of knowledge. (Emilia, interview #1, March 2006)

I wonder about the thinking behind these placement policies. Not only are parents not aware of the implications of this policy on their children's learning (or not) of mathematics, but also teachers often are not either as Anhalt, Ondrus, and Horak (2007) show. In their article they describe the reactions of a group of middle school mathematics teachers after they played the role of students in a mathematics class taught in Chinese. As the teachers reflected on this experience in relation to their own work with English Language Learners (ELLs), they realized that in some cases they had not paid any attention to the Chinese language and had focused on the mathematics that they already knew. Hence, they wondered about this placement policy that places ELLs in lower level mathematics with the idea that it will help them learn English. Teachers questioned whether through this practice, students would learn neither English nor mathematics. Experiences such as this one can be quite powerful in addressing some of the beliefs that teachers seem to have about language and the teaching and learning of mathematics.

### **Research with immigrant parents**

In general terms, research on parents and mathematics education is rather limited. In the U.S., for example, there has been some research on parents' views of reform mathematics. For this review, however, our goal is to focus on research with immigrant parents and their views of mathematics education. Most of the research I found on this topic was done by Abreu and her colleagues in the U.K. (Abreu & Cline, 2005; Abreu, Cline, & Shamsi, 2002; O'Toole & Abreu, 2005) and by Civil and her colleagues in the U.S. (Civil & Andrade, 2003; Civil & Bernier, 2006; Civil, Bratton, & Quintos, 2005; Civil & Quintos, 2006; Civil & Quintos, 2008; Quintos, Bratton, & Civil, 2005). Civil, Planas, and Quintos (2005) and Civil, Planas, and Díez-Palomar (2007) look into immigrant parents' perceptions about the teaching and learning of mathematics in two different geographic contexts, Barcelona, Spain, and Tucson, U.S.

Besides these studies in U.K., U.S., and the one study with immigrant parents in Barcelona and in Tucson, I found one study with immigrant parents in Germany. Hawighorst (2005) presented a study on parents' conceptions and attitudes towards mathematics. She focused on three different groups of parents: German parents; resettler parents of German descent (from the former Soviet Union); and Turkish parents. Her interviews covered topics also addressed in the research by Abreu and her team, and by Civil and hers, namely, the importance and uses of mathematics in their everyday life, parents' experiences with their own learning of mathematics, as well as parents' views on their children's mathematics instruction.

There are three (related) themes that emerged and that cut across all immigrant parents in these studies. Overall, immigrant in the four geographic contexts shared a concern for a lack of emphasis on the "basics" (e.g., learning of the multiplication facts) in the receiving country, a perception that the level of mathematics teaching was higher in their country of origin, and a feeling that schools are less strict in their "new" country. There is something quite remarkable in reading some of the quotes from the parents in that while they are coming from very different countries (e.g., Pakistan, Mexico, Morocco, Turkey),

what they say is almost identical, when sharing their perceptions about their children's mathematics education in their "new" country.

Abreu and colleagues as well as Civil and colleagues have looked at these themes in some depth, thus providing an analysis related to issues of differences in approaches, issues of valorization of knowledge, and potential conflict as children are caught between their parents' way and the school's way. As Quintos, Bratton, and Civil (2005) write, "the knowledge that working class and minoritized parents possess is not given the same value as that which middle class parents possess" (p. 1184). They go on to address this topic of valorization when it opposes home and school knowledge:

Alternative approaches are often not treated equally.... In this context, the parents' or home method is not given the same value as the teacher's or textbook method. Historical relations of power at the schools can not only be reproduced but also exacerbated through mathematics education. (p. 1189)

The research with immigrant parents and their perceptions of the teaching and learning of mathematics underscores the need for schools to establish deeper and more meaningful communication with parents. Parents tend to bring with them different ways to do mathematics that are often not acknowledged by the schools, and vice versa, parents do not always see the point in some of the school approaches to teaching mathematics. Although this may be the case with all parents (e.g., in the case of reform vs. traditional mathematics), the situation seems more complex when those involved are immigrant parents and their children. As the research of Civil and colleagues shows (Civil, in press; Civil, Díez-Palomar, Menéndez-Gómez, Acosta-Irriqui, 2008; Civil & Planas, 2008) differences in schooling (different approaches to doing mathematics) and in language influence parents' perceptions of and reaction to practices related to their children's mathematics education. In particular, there is evidence that when English is the only language of instruction (e.g., in the case of our local context in the U. S.), there are cognitive and affective implications.

### **Research approaches and constructs**

As I read the different articles for this review, there seemed to be some concepts (constructs) that appeared in more than one piece (e.g., the concept of identity). What I try to do in this section is to highlight some of these concepts, as well some of the theoretical approaches that appear to dominate this field of research. I also include some concepts that although maybe were only found in one or two researchers' work, I thought they were an important addition to the field.

Most of the articles reviewed fall within the general framework of sociocultural research. The work of Alrø et al. (2005; 2007) and Valero (2007) take a socio-political approach (see also, Valero & Zevenbergen (2004) for a collection of articles with a socio-political framework). Researchers such as Bartell (2005), Gutstein (2003; 2006; 2008), Turner and Varley (2008) use a social justice lens in their research. Nasir et al. (2008) give a thorough overview of research projects in the U.S. that seek to bridge in-school and out-

of-school mathematics and projects that take a social justice approach to the education of non-dominant<sup>4</sup> students.

What seems clear from this review of the literature is that research on the teaching and learning of mathematics of immigrant students is strengthened if interdisciplinary teams are involved. There is a need for interdisciplinary research teams that combine expertise on mathematics and mathematics education, as well as immigration issues (including language, social and cultural elements). In order to understand the educational context of immigrant students, mathematics education researchers have to go outside mathematics education to gain deeper insight into issues of language, social, political and cultural context, among others. In going outside the field of mathematics, I have found myself often asking the question “where is the math?” I have raised this question often in my work on bridging in-school and out-of-school mathematics (see for example, Civil, 2007), but also it is a question that I ask now of the emergent scholars in CEMELA. It is, I believe, an important question, since those of us engaged in this research risk being categorized as not having mathematics play a “prominent” role in our writing (this is a feeling shared by several people I have talked to not only in the U.S. but, for example, also in Spain; and this issue has implications for where we publish). As I work in my area of interest—the mathematics teaching and learning of immigrant students—I find myself reading outside the mainstream mathematics education journals. I need to develop a wider knowledge base in order to understand immigrant students’ experiences. I agree wholeheartedly with Valero’s (2004) need to “challenge the discourse.” As she writes,

Most mathematics education research talks about the universal, normal child and how she thinks mathematically. But, what is the problem? you may ask. Mathematics education is about mathematical learning and there is no learning without an emphasis on either the learner or the mathematics. *My* argument goes in the direction that there is much more at stake than that kind of learner when talking about mathematics education. (p. 40)

Valero goes on to “review” some key pieces in mathematics education research with a critical lens focusing on the unproblematic nature of these descriptions: who were the children? What do we know about the context in which the research took place? Even when some of these studies do provide more context, Valero writes,

Despite the enlargement of the notion of the students’ context here, it seems that the elements of the *sociopolitical context* of the students, as fully historical members of a large society, dilute when participating in a mathematics community of practice. The different discursive constructions mentioned above oppose the nature of the students that one meets in real classrooms. (p. 44)

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<sup>4</sup> I am borrowing the term “non-dominant” from K. Gutiérrez (2005) who writes, “The term non-dominant is used here instead of the more commonly used terms of ‘minority,’ ‘diverse,’ or ‘students of color,’ as we believe this term better addresses issues of power and power relations than do traditional terms” (p. 3).

She then turns to the case of two students in her research in a school in Colombia and the need to understand and make explicit these students' sociopolitical context in any account of their experiences as learners of mathematics. This is a key aspect in the work with immigrant students, as I have illustrated in this review.

An important concept in Valero's work (as well as in that of others, e.g., Gorgorió and Planas (2005b); Civil, Planas, & Quintos (2005)) is that of macro and micro context. As Valero (2008) writes in her reflection on doing research in situations of poverty and conflict,

The macro-context and all its harshness are vividly present—sometimes almost physically present—in many classrooms. If this is the case, research that re-conceptualizes the impact of the macro-social world in the micro-social world is necessary. (p. 162)

She then calls for the need to develop theoretical tools that will allow us to address the complexity of research in these situations of poverty and conflict and that takes into account both the micro and the macro contexts. Although in a different context, Knipping, Reid, Gellert, and Jablonka (2008) also bring up the methodological challenges for bringing the micro and the macro together. In their case, they are wondering about how to study the “discursive and interactive dynamics that produce disparities in the mathematics classrooms (the ‘micro-perspective’), while taking into account the socio-cultural structures of our societies (the ‘macro perspective’)” (p. 326).

A group of researchers from one of the Centers for Learning and Teaching, DiME (Diversity in Mathematics Education) authored a chapter called “Culture, race, power, and mathematics education” (DiME, 2007). This chapter provides an insightful overview of some key constructs that are very present in articles reviewed here, namely: power, identity, participation, discourse. For example, of importance to those of us working with immigrant students is a better understanding of immigrant students' everyday discursive practices and their implications for our analysis of their teaching and learning of mathematics. In terms of pedagogical approaches, this chapter by DiME highlights culturally relevant pedagogy, teaching for social justice, and bridging out-of-school and in-school mathematics, which is also discussed in detail by Presmeg (2007). These constructs and approaches are also addressed in Nasir et al. (2008).

The concept of identity is probably one of the most prominent in the research reviewed. Researchers such as Abreu (2005), Chronaki (2005), Elbers (personal communication), Stathopoulou and Kalabasis (2007), among others, use this term in their research. Stentoft's (2007) contribution is devoted to a discussion of the concept of identity in research in mathematics education. She takes the generally shared view of identity as dynamic and argues that this concept of identity allows us to move beyond focusing on specific (static) characteristics such as gender, race or ethnicity. Of course, what is meant by identity varies, and Sfard and Prusak (2005) have written very insightfully about the need to define this term. “Identity” is certainly a key concept among young scholars, such as the ones working in CEMELA (e.g., Díez-Palomar, Varley, and Simic, 2006;

Domínguez, 2007; Quintos, 2008; Radosavljevic and Willey, 2007; Turner and Varley, 2008).

Jilk (2007), an emergent scholar whose dissertation focuses on four Latino (from four different countries in Latin America) young women's participation in school mathematics, uses identity as a key construct in her research. She writes:

I used identity as a research construct, because I thought it would help me to better understand why and how these young women chose to participate in their high school mathematics classes. However, I did not want to impose an identity framework on my data or analysis for several reasons. First, because I assumed that my life experiences as a middle-class White woman who grew up in the Midwestern U.S. were probably very different from the young women in my study, and I did not want *my* definitions of Latina or immigrant or female to interfere with what I had to learn from the young women. Nor did I want to assume that my identity categories were necessarily important to them. (...) Therefore, my goal was to begin with the identities that each of my participants designated as most salient and the meaning she assigned to this "salient identity." This approach garnered interesting results as the young women named identities and assigning meanings to them that an outside researcher might never consider, such as religion, "somebody," "feminist," and "liberal." (L. Jilk, personal communication, May 2, 2008)

Jilk's findings are very relevant for those of us working with immigrant students and mathematics. Her in-depth study of these four young women advances our understanding of the concept of identity. Furthermore, the characteristics of the learning environment that seemed to help these students develop an identity as successful learners of mathematics have direct implications for practice and teacher education. I want to point out two such characteristics, "the use of home language in the mathematics classroom and the valorization of multiple methods for thinking about and doing school mathematics." As she points out:

Students use their identities to read their mathematics classrooms. They are constantly translating teacher moves, curricular goals, and social norms for participation and learning through the lenses of their identities. In this way, identities become funds of knowledge for students to use as tools for learning mathematics.

In addition to learning mathematics, mathematics classrooms can be sites for further identity development.... The narratives of my participants suggest that there were specific features of [their] classrooms that supported their continued engagement with mathematics and simultaneously their development of salient identities. These features were: a multi-dimensional version of school mathematics, the use of home language in the mathematics classroom, collaborative groups and norms for working with groups, and the valorization of multiple methods for thinking about and doing school mathematics. (L. Jilk, personal communication, May 2, 2008)

Jilk (2008) refers to her using narrative methods to capture the voice of the four students. Stentoft (2005) stresses the importance of dialogue to study diversity and for the need to make sure the participants' voices are heard. This methodological approach of focusing on the participants' voices seems to be shared by several researchers who are working in this topic. This is certainly the case of the work with immigrant parents carried out by Civil and colleagues (Civil, 2002a; Civil & Andrade, 2003).

Finally, one last construct that seems prominent in the research in this field is that of social representation (Abreu & Gorgorió, 2007; César, Abreu, & Gorgorió, 2007; Gorgorió & Planas, 2005b; 2005d; Gorgorió, personal communication). For example, Abreu and Gorgorió (2007) examine the “processes through which teachers and students ‘take on’ (Howarth, 2006), make use of, and transform specific social representations to mediate their practices... Social representations are not just something one uses to inform one’s practices, but something that becomes part of one’s reality” (pp. 1559-1560).

### **Limitations and implications for further research**

Very likely, this survey of research has many gaps. I had to find a way to organize how I was going to conduct the survey, and in so doing I made choices that put some contributions in and left some out. To begin with, I focused primarily on articles and papers that explicitly talked about mathematics education and immigrant students. This means that many articles that present important research on issues of diversity or paper addressing theoretical or methodological approaches that should be relevant to this topic of study may have been left out. I did try to include some of those, but my emphasis was on empirical work done with immigrant students, immigrant parents, or teachers of immigrant students.

Most of my focus was on research with immigrant students in Europe, hence, many other parts of the world are not represented (and even many parts of Europe are not represented!). I relied on proceedings from recent conferences and on contributions from researchers on this topic. I know I missed many. For the work in the U.S., I only focused on the research with Latino/a students, as this is the largest group of immigrants at the moment. Even there, I most likely missed research studies that should have been mentioned. Furthermore, there is a clear gap in that, except for the work of Susan Staats, I do not report on research with less talked about immigrant groups in the U.S. (at least in terms of their mathematics education), such as the Hmong students or the Somali. As Staats says reflecting on her work with Somali students in the U.S., “I think the Somali situation highlights the need for different kinds of interventions for different students.” (S. Staats, personal communication, June 8, 2008). Staats’ comment points to the need to not view all immigrant students as “the same.” In thinking of immigrant students, there is a risk to essentialize these students, as we often essentialize students within other groups, such as Latinos/as, when it is well known that there are vast differences among the various groups of Latinos/as. Or, as Swapna Mukhopadhyay (Portland State University, USA) writes about Asian immigrants in the U.S., we need to:

Critically examine the myth that all Asians excel in school math. Is class (and

social capital) an integral part of what makes the Asian kids do well? (Also, what role does complacent/highly adaptive behavior play in attributing their "success?") Asian-Americans signify a very large group of people from highly diverse cultural and economic background. Is there a difference between the blue-collar/transient Asians versus the affluent middle and upper middle class professional? For example, how do the children of taxi drivers do versus that of the doctors? I have a feeling that the achievement/school performance is bounded by class, privilege and access. (S. Mukhopadhyay, personal communication, June 8, 2008).

My hope is that through this review, we will hear from other researchers who are working in mathematics education and with immigrant students and that we will be able to elaborate further on this work, which I consider a work in progress. Having said that, however, there are several implications that this review points to and that I want to briefly mention here.

Abreu, César, Gorgorió, and Valero (2005) raise two important questions that should frame, I think, further research in this field. They write, “Why research on teaching and learning in multiethnic classrooms is not a bigger priority? Why issues of teaching in multicultural settings are not central in teacher training?” (p. 1128)

Based on the research reviewed, there seems to be a clear need for action-research projects with teachers of immigrant students engaging as researchers of their own practice to counteract what appears to be a well-engrained deficit view of these students and their families. Through a deeper understanding of their students’ communities and families (e.g., their funds of knowledge), maybe teachers can work towards using different forms of doing mathematics as resources for learning instead of the current trend that seems to view diversity as an obstacle to learning (there are of course exceptions to this view and I have addressed those in the review). Related to this idea of understanding immigrant students’ communities, there is very little research looking at the sending communities. That is, what do we know about the teaching and learning of mathematics in the countries / communities that these immigrant students came from? As Jilk writes,

Interestingly, much research in multicultural education points to the many ways in which students’ home and school experiences in another country impact how they think about and act in relation to their schooling experiences in the United States, yet it is extremely rare for such information to be considered with respect to school mathematics. (L. Jilk, personal communication, May 2, 2008)

We have recently started one such project in CEMELA, in which we look at the mathematical experiences of the students who are recent immigrants to the U.S. by studying the teaching and learning of mathematics in some sending communities. Specifically, we are looking at mathematics instruction at one school in Mexico across the border from Arizona to gain a better understanding of Mexican teachers’ conceptions about the teaching and learning of mathematics. I argue that there is a need for more

research along these lines to gain a better understanding of the background experiences of immigrant students.

There is also a need to analyze the learning conditions in schools with large numbers of immigrant students. What Nasir et al. (2008) write in reference to African American and Latino and poor students is likely to be the case with immigrant students in many countries:

African American and Latino students and poor students, consistently have less access to a wide range of resources for learning mathematics, including qualified teachers, advanced courses, safe and functional schools, textbooks and materials, and a curriculum that reflects their experiences and communities. (p. 205)

Issues of valorization of knowledge and different forms of mathematics need to continue to be explored, as there are many open questions still. Related to this is the idea of non-immigrant students' views of immigrant students. This topic has received very little attention (a notable exception is the work of Planas in Planas, 2007; Planas & Civil, in press), yet it seems like it would be important to understand how all the students see and understand the experience of being in a multicultural classroom (Alrø et al (2007) address this topic to a certain extent).

Another area that needs further research is that of immigrant parents' perceptions about the teaching and learning of mathematics. It is certainly interesting to note the similarities in these perceptions across very different contexts of immigration. "What now?" is my question. Furthermore, an important and under-researched area is that of interactions between immigrant parents and teachers and perceptions of each other's in terms of the children's mathematics education. Civil and Bernier (2006) address this to a certain extent, but much more work is needed, especially given the need for a holistic approach to the education of immigrant students that really includes multiple voices, and the different participants in this education (parents, teachers, school administrators, community representatives, and the students themselves).

Language is a prominent theme in the research with immigrant students and mathematics education. More research is needed that focuses on multiple languages as resources for the teaching and learning of mathematics, once again to counteract the deficit perspective, particularly in the public discourse that sees the presence of other languages and the not knowing the language of instruction as obstacles to the mathematics education of immigrant children. Issues of placement based on language proficiency and the impact that these decisions have on students' learning of mathematics also need to be studied further.

In reflecting of what needs to happen next, Philip Clarkson writes:

We know quite a lot about multilingual kids' learning. But we have not been very good at looking at the varying multilingual contexts in which that learning takes place. Are we making too many assumptions there?

In the last 10-15 years we are moving to look at teaching, but much more needs to be done with this. What models are there available that teachers can use as guides? Are they sorted according to the multi lingual context of the classroom? What do we need to do now? What do we think would be good places to search that we think will move us forward to greater insight? (P. Clarkson, personal communication, May 27, 2008).

Also, I want to reiterate here Barwell's message as a clear implication for research in this area:

There is another dimension, however, in which I see little change - that is the broader acknowledgment of multilingual issues (and multicultural issues) in research in mathematics education more generally. Most classrooms these days can be described as multilingual and/or multicultural in some way and, for me, this potentially has major implications for doing research - the methods we use, the theories we use, and the way we interpret and analyse our data. It concerns me how rarely researchers mention whether the participants involved in their studies are working in their main language, for example, or in an additional language. (...)

I think we have succeeded in getting multilingual issues recognised as a legitimate area of concern within mathematics education...the challenge now is to get it recognised as relevant across the field. The other challenge is to find ways to include greater language diversity in our field. (R. Barwell, personal communication, May 10, 2008)

Finally, a clear implication from the research reviewed on this topic is the need for interdisciplinary teams with expertise in different areas including mathematics education, immigration policy, linguistics, socio-cultural theories, anthropology, just to name a few. There is a clear need for this interdisciplinary expertise, as well as for the development (or refinement) of theoretical and methodological approaches. I find Valero's (2008) comment on this (in the context of mathematics education in situations of poverty and conflict, which are quite the norm in immigrant contexts) very insightful:

The theories that have been used to study mathematics learning build on a fundamental assumption of continuity and of progression in the flow of interactions and thinking leading to learning. (...)

When [these theories] are simply applied without further examination the result has often been the creation of deficit discourses on the learners or the teachers. (...) The question then becomes how can (mathematics) "learning" be redefined as to provide a better language to grasp the conditions and characteristics of thinking in situations where continuity and progression cannot be assumed. (p. 161)

I leave the reader with the challenge Valero raises in the last sentence.

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Recent studies support the necessity of teachers'™ intercultural sensitivity to effectively handle the implementation of such measures (Spithourakis et al, 2009). This fact has also been observed by teachers themselves, who in turn consistently request additional teaching training on intercultural education and teaching (Spithourakis & Katsillis, 2003; Tressou & Mitakidou, 1997). Available at: <http://ermeweb.free.fr/CERME4/> Civil, M. (2008) Mathematics teaching and learning of immigrant students: A look at the key themes from recent research. ICME Survey Team 5: Mathematics and Education in Multicultural and Multilingual Environments, Monterrey, Mexico, July 2008. If their students are to develop mathematical proficiency, teachers must have a clear vision of the goals of instruction and what proficiency means for the specific mathematical content they are teaching. They need to know the mathematics they teach as well as the horizons of that mathematics—where it can lead and where their students are headed with it. They need to be able to use their knowledge flexibly in practice to appraise and adapt instructional materials, to represent the content in honest and accessible ways, to plan and conduct instruction, and to assess what students are learning.