Cult Stud of Sci Educ (2016) 11:41–59
DOI 10.1007/s11422-014-9648-2

STEM learning research through a funds of knowledge lens

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Received: 2 October 2014 / Accepted: 2 October 2014 / Published online: 21 October 2014

Abstract This article examines STEM learning as a cultural process with a focus on non-dominant communities. Building on my work in funds of knowledge and mathematics education, I present three vignettes to raise some questions around connections between in-school and out-of-school mathematics. How do we define competence? How do task and environment affect engagement? What is the role of affect, language, and cognition in different settings? These vignettes serve to highlight the complexity of moving across different domains of STEM practice—everyday life, school, and STEM disciplines. Based on findings from occupational interviews I discuss characteristics of learning and engaging in everyday practices and propose several areas for further research, including the nature of everyday STEM practices, valorization of knowledge, language choice, and different forms of engagement.

Keywords Mathematics education · Funds of knowledge · In-school and out-of-school learning · Non-dominant groups · STEM practices · Valorization of knowledge

The editors of this special issue charged me with "examining learning as a cultural process, involving varied repertoires of practice across learners' everyday lives, particularly in non-dominant communities, seeing how these connect with practices in STEM disciplines." Much of my research has focused on exploring connections between mathematics in everyday life and school mathematics, particularly in working class, Latina/o communities.

L. D. Dierking and J. H. Falk, Editors for Special Issue, 2020 Vision: Envisioning A New Generation of STEM Learning Research.

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Hence, while I think that some of the observations I make can probably be extended to STEM learning research in general, some may be more specific to the discipline of mathematics. In this article I first give some background motivation for my research interest in learning as a cultural process and describe some of the theory behind my work, in particular the concept of funds of knowledge. Then I use three vignettes grounded on my research to illustrate some dilemmas I have encountered in looking at possible connections between in-school and out-of school mathematics. In the final part of the article I present some suggestions for next steps in research within this perspective of seeing learning as a cultural process and the implications that this poses for research in mathematics education.

My dilemma around school and everyday mathematics

My entry into the world of mathematics education research was through my experiences teaching mathematics content courses for prospective elementary teachers. In particular, at the beginning of my career, I often taught a course centered on exploring whole numbers and rational numbers. The students were predominantly female and white, ages 19–21. According to their mathematical autobiographies, many of these students had not had very good experiences as learners of mathematics in school, and expressed some apprehension towards the subject. I started teaching using an approach that emphasized students' participation in meaning-making, through small group discussions of problem-solving tasks and moved away from a lecture-based approach. While some students were visibly uncomfortable with an approach in which they had to discuss mathematics with their peers, look at and for different approaches to problems, and in general move away from a procedural, formulaic approach to doing mathematics, others embraced this discussion-based approach as a liberation. This was the case of Vicky, a prospective teacher who was older than the typical student in these courses. Vicky had not attended college right after high school. She had raised a family and then decided to pursue a college degree. My course was her first mathematics course in 12 years. In her journal, Vicky wrote, "I had fun today. In fact, I found myself looking forward to class… There is hope yet when I can legally use my methods to solve a problem."

Vicky did indeed approach problems in non-formulaic ways, often trying to connect them with her experiences in everyday life. I could see these connections playing a role in her conceptual understanding of problems. One example was in a fairly typical word problem: "If you need 1 1/3 cups of sugar and 4 cups of flour to bake a cake, how many cups of sugar will you need if you want to use 7 cups of flour." While most students used a classic approach of setting up a proportion and "solving for x," Vicky drew the cups of sugar and flour and used her drawings to correctly reason how to adjust the recipe for a different number of cups. Vicky often described her approach to problems as "a process of elimination" by which she seemed to mean a guess and check type of process. Her "guess and check" was grounded on a solid and concrete understanding of the problem. Yet she did not seem to value her method as much as her peers' use of algebraic methods. For example, after she had successfully reasoned through how to find a base b for which $(204)_b = (76)_{ten}$, she said to one on her peers, "if you can do it the algebra way and show me. I just can't. My problem is that I see the problem and I think back to doing it on the table." By "doing it on the table" Vicky was referring to visualizing the place value chart and the trading chips we had been using in our work with different bases. Her peers had tried, unsuccessfully, to solve the problem using algebra. One of them, perhaps recognizing the generalization aspect of an algebraic approach, asked Vicky "if you had like two, two, four [meaning $(224)_b$] would you have done it the same way?" to which Vicky replied that she did not know and that "most of my math is a process of elimination." To me, this implies a possible tension between the power of generalization that is often attributed to school mathematics (and in particular to algebra) and the more context-specific method that one may use to solve everyday problems, an old and yet still recurring theme (Resnick 1987). That is, Vicky approached each problem with "this process of elimination" that meant an approach adapted to the problem in hand. Hence, when one of her peers asked her if she would have done it the same way for $(224)_b$, Vicky's reply that she did not know makes sense because indeed $(224)_b$ may have called for a different approach from the one she used for $(204)_b$.

Algebraic approaches were generally privileged by the students in this course (as well as by many others in my many years of teaching mathematics content courses for preservice elementary teachers). I want to make clear, though, that this privileging did not mean that students were necessarily proficient at using algebra or that they appreciated its power of abstraction and the concept of generalization. It seems to be more the result of how algebra is often portrayed in school mathematics. Students from as early as elementary school know of the "powerful" presence of algebra. There is this sense of high status associated with being good at algebra, as the case of Vicky and her peers illustrates. In this course it was clear that these prospective teachers privileged school-looking methods over those that were grounded on everyday approaches. Expressions used by students in this course and others to describe their methods when they were not algebra or formula-based include, "working out the problems the long way [is] tedious and stupid", "[algebra] is a better way to go about it than my prehistoric way."

Elsewhere (Civil 2002a), I give several examples to illustrate my dilemma between the students who try to make sense out of mathematics by bringing in their everyday knowledge and those who seem to view these two worlds (in-school and out-of-school) as completely separate:

> I became intrigued by the fact that the 'more successful' [students] were less likely to make use of 'informal' methods, everyday type reasoning, and would rather use a formula, algebra, school-like methods. The 'less successful' were often trying to make sense of the problems, making connections to everyday life. (Civil 2002a, p. 135)

By "more successful" I mean students who had had more success at playing the school game by its rules. That is, these were students who, while they would not describe themselves as being strong in mathematics, had managed to get through the required courses and they had a clear sense of what it meant to do mathematics in school (Civil 1990). Some of these students seemed aware that they had to think more when using non-formulaic methods, and recognized that they were using algebra by rote, through their extended practice with similar problems in high school. But still, there was a shared sense that these school-mathematics methods were to be preferred. These experiences with prospective teachers, and in particular how they viewed each other as being more or less knowledgeable about mathematics based on a valuing of school mathematics and a devaluing of everyday mathematics became central to the shaping of my research agenda. In the next section I briefly summarize some key ideas from situated cognition, ethnomathematics, out-of-school mathematics, and valorization of knowledge that are part of my theoretical framework.

Some ideas from research on out-of-school mathematics

Studies on situated cognition (Brown, Collins and Duguid 1989) and on out-of-school mathematics (Nunes, Schliemann and Carraher 1993) became key to the development of my research agenda. In particular the notion that the context in which a task takes places affects performance intrigued me, as I was seeing evidence of this happening in the mathematics content courses for preservice elementary teachers. For me a question became, "how can we build on students' knowledge and experiences in everyday life, in such a way that these become relevant and useful for the teaching and learning of school mathematics?" But as I reflected on the preservice teachers' comments on the different approaches to solving problems and how they seemed to believe that the school-based approaches were "better" than their everyday or informal approaches, I realized that I needed something other than the concept of beliefs (which was my original framework) to make sense of what I was noticing. An article by John Spradbery (1976) on the opposition of a group of students towards an innovative approach to the learning of mathematics brought up the issue of value and status to my attention. The innovative approach sought to build on students' out-of-school experiences with keeping and racing pigeons, as a way to address their lack of success with traditional school mathematics. However, as Spradbery writes,

> Although the mathematician may regard certain aspects of pigeon-keeping (along with many of the other daily activities of children) as being 'mathematical', such knowledge appears to have little value or status in the classroom. For 'Maths' to be 'Maths' (or 'proper Maths', as a number of children described it) it has to be separated from other everyday knowledge. (p. 237)

In my own work I have documented tensions along the lines of those alluded to by Spradbery, as we tried to develop teaching innovations that built on students' everyday, out-of-school experiences but at the same time connected with the school mathematics that students were expected to learn (Civil 2002b). As Guida de Abreu (1995, p. 119) writes, "although home and school mathematics could be characterized as distinct cultural systems of representation it is not clear if someone who is exposed to different systems will experience them as independent or as interdependent." In that same article, Abreu explores how children from a rural sugar cane farming community in Brazil view the relationship between home mathematics and school mathematics and writes, "if we want to understand why a child successful in out of school mathematics does not use his knowledge to inform the solution of school problems, we might want to ask about the valorization of the two practices" (p. 122).

The notion of valorization has since become a key construct in my research. Guida de Abreu and Tony Cline (2007) write:

> Valorization is a relational construct. The same practice can be valorized or devalorized, depending on its positioning in a web of social and historical relations, which is relevant for the group or participant in a practice. Like currency, valorizations are not fixed. At a particular point in time they can change, depending on the positioning one takes on. (p. 121)

The concept of valorization of knowledge is particularly relevant when working with non-dominant communities, as for example in my work with Latina/o parents and their children. Immigrant parents who were schooled in their countries of origin are likely to bring in approaches to doing mathematics that are different from the ones that their children are learning in schools in the US. While these parents may give high value to their approaches (e.g., as being more efficient than the approach their children are learning, Civil and Planas 2010), teachers may not necessarily embrace these "other" approaches, hence placing children in a difficult position as they attempt to navigate different practices with different valorizations depending on where they are (home/school).

Embedded in this discussion on valorization is the notion of different forms of mathematics, whether it is everyday mathematics (as in Abreu's (1995) case, sugar cane farming mathematics) and school mathematics; or even within school mathematics, different forms as in the case of immigrant parents and their school mathematics versus their children's current school mathematics. The notion of different forms of mathematics is addressed by the concept of ethnomathematics, to which I turn next.

As Norma Presmeg (2007) discusses, there are multiple interpretations to the term "ethnomathematics." My introduction to this term was through Ubiratan D'Ambrosio's (1985) definition, in which he defines "academic mathematics" as the "mathematics which is taught and learned in the schools" (p. 45). He then writes:

> In contrast to this we will call *ethnomathematics* the mathematics which is practised among identifiable cultural groups, such as national-tribal societies, labor groups, children of a certain age bracket, professional classes, and so on. Its identity depends largely on focuses of interest, on motivation, and on certain codes and jargons which do not belong to the realm of academic mathematics. (p. 45)

Although this definition is quite encompassing, most of my initial readings in this field focused primarily on two kinds of studies: those documenting the mathematics in the practices of specific indigenous groups, often in terms of a craft or artistic activity (e.g., Ascher 1991) and those documenting the mathematics in some occupations such as Wendy Millroy's (1992) study of carpenters or Joanna Masingila's (1994) study of carpet layers. These studies illustrate the use and presence of mathematics in a variety of settings and thus move us away from mathematics as only happening in a school setting. However, I think it is important to keep in mind Paul Dowling's (1998) critique, particularly when working with non-dominant communities. He writes, "to varying degrees, all of this work [in ethnomathematics] succeeds in celebrating non-European cultural practices only by describing them in European mathematical terms, that is by depriving them of their social and cultural specificity" (p. 14). While Dowling seems to be referring mostly to the ethnomathematics studies that look at the mathematical content in practices in "other" cultural settings (e.g., of non-European origin), I think that the same critique in his statement can apply to all forms of mathematization of practices in general. That is, when we take a practice and attempt to describe its mathematical content, which mathematics are we imposing? Are we viewing the practice through a lens of academic mathematics? If learning is a cultural process, what are the implications of depriving practices of "their social and cultural specificity"? What would it look like to view practices through a lens of everyday mathematics?

What is everyday mathematics? That was the question that I faced when I moved away from the initial readings in ethnomathematics (i.e., the practices of indigenous groups; mathematics in specific occupations). While these contributed greatly to my thinking, what seemed to be more elusive to me were the mathematical experiences that we may all engage in as part of our everyday life. And understanding these everyday experiences is what I needed in my local context of heterogeneous, non-dominant, borderland communities. Hence, the question I posed earlier, "how can we build on students' knowledge and experiences in everyday life, in such a way that these become relevant and useful for the teaching and learning of school mathematics?" This question was a key motivation for me when I joined the Funds of Knowledge for Teaching (FKT) project that I describe next. The concept of funds of knowledge forms the basis of the theoretical framework for the work I discuss in this article.

The funds of knowledge for teaching project

I joined the FKT project shortly after my arrival to the University of Arizona. My first experience was through a teacher-researcher study group, where teachers and university researchers were discussing and analyzing findings from household visits with an eye on developing learning modules that would build on these findings. Teachers followed an ethnographic approach to the household visits supported by three detailed questionnaires that covered family history and labor history; household activities; and parental attitude. One of the teachers in the project writes, "ethnographic home visits are designed to establish a relationship of mutual trust while eliciting personal narratives from members of households" (Floyd Tenery 2005, p. 128).

At the center of this project was, of course, the concept of funds of knowledge. Luis Moll, Cathy Amanti, Deborah Neff, and Norma González (2005, p. 72) write, "we use the term *funds of knowledge* to refer to these historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being."

In summary, the primary goal of the FKT project was the development of teaching innovations that built on the background, knowledge, and experiences (i.e., the funds of knowledge) of students, their families and their community. As Luis Moll (1992) describes, the FKT project is based on a sociocultural perspective on teaching and learning, capitalizing on "how social practices and the use of cultural artifacts mediate thinking… classrooms (or households) are always socially and culturally organized settings, artificial creations, whose specific practices mediate the intellectual work children accomplish" (p. 21). For a detailed account of the FKT project, I refer the reader to Norma González, Luis Moll and Cathy Amanti (2005). My focus in this article is on some of the implications that I see for STEM learning research from a funds of knowledge point of view.

A funds of knowledge approach focuses our attention on the culturally situated everyday practices. It is grounded on a dynamic view of culture as lived experiences: "the focus is on 'practice,' that is, what it is that people do and what they say about what they do. The processes of everyday life, in the forms of daily activities, emerge as important" (González 2008, p. 96). After the FKT project ended, we extended it to project Bridge (Linking home and school: A bridge to the many faces of mathematics), which had an explicit focus on mathematics. Given the focus on mathematics, I tried to uncover the mathematics embedded in these everyday practices that we documented through the home visits and occupational interviews we did. I certainly experienced Millroy's (1992, p. 11) paradox, "how can anyone who is schooled in conventional Western mathematics 'see' any form of mathematics other than that which resembles the conventional mathematics with which she is familiar?" While, at least in my perception, the transformation of household knowledge for literacy experiences in school seemed to have been relatively unproblematic, the connection between household knowledge and school mathematics seemed more elusive (González, Andrade, Civil and Moll 2001). For example, during one study group session in project Bridge, in a discussion of the mathematics embedded in the practice of sewing, one of the teachers asked, "if you have too much school mathematics, does it erase our practical mathematics?" As this teacher's question reminds us (and my experience with preservice elementary teachers corroborate), the connection between school mathematics and out-of-school mathematics is not only missing, but it is almost as if trying to make this connection may actually be to the detriment of one or the other.

So far in this article most of the discussion around funds of knowledge type projects has focused on the connection between everyday practices and school teaching and learning, as that was the primary goal of these projects, namely to transform the schooling experience of non-dominant, marginalized students. That is, I was largely working on approaches to school mathematics that built on, valued, and reflected the everyday mathematical practices of non-dominant students. But since STEM learning is a lifelong process and it is not limited to formal settings such as schools, what are the implications of a funds of knowledge approach for next steps in research that looks at this lifelong process in non-dominant communities and its possible connections to STEM disciplines? To address this question, I argue for the need to focus on the characteristics of engagement in everyday practices (with an eye on mathematical practices). In the next section I present three vignettes from my research in non-dominant communities to illustrate aspects of engagement in a mathematical practice. The three vignettes move across both settings, in-school and out-of-school. I use these vignettes to anchor a follow-up discussion around the question of possible next steps for STEM learning research.

Three vignettes around in-school and out-of-school mathematics

Vignette 1: How do we define competence?

Elsewhere (Civil and Andrade 2002), we discuss the case of Alberto, a 10-year-old Mexican boy who had moved to the US with his family less than a year before our home visit took place. He was in a fifth grade bilingual classroom with a teacher who was part of the FKT project. In class, Alberto alternated between being somewhat withdrawn to mildly disruptive. In terms of academics, he appeared to struggle with some "basic" areas, including arithmetic. The teacher was concerned that she was not having much success reaching out to him. She decided that she needed to understand more about his background and his family's experiences and history, as a way to hopefully connect with him and provide a more meaningful schooling experience. So she chose him as the student for her funds of knowledge household visits and I accompanied her on her first visit. In that visit with Alberto's mother, we learned two key things that shed light on Alberto's behavior and performance in class. The first piece of information we learned was that Alberto was the middle child (out of three boys), and he was the only one who did not want to move to the US. So, while his brothers were happy with the move and were adjusting well, Alberto did not want any part of this. The second item was that while in Mexico, Alberto helped with the family business, a bakery. Every day, after school he went to the bakery, picked up the different orders and delivered them to his set of costumers. According to his mother, he handled everything involved in these transactions—taking in and delivering the orders and keeping track of the money. Both Alberto and his mother expressed how much he enjoyed being responsible for this group of customers.

By many indicators, Alberto was "at risk" of failing in school. He was in fifth grade, hence getting ready to transition to middle school. He was an English language learner. He was not doing well academically (by typical school measures). Yet, during the home visit we saw a different image of Alberto. His mother spoke of him with pride, as she described him as a successful young boy who was clearly competent at commercial transactions and responsible for more aspects of his family's everyday life than probably fifth graders in more economically privileged settings. Alberto's case is just one of many throughout the funds of knowledge work that illustrates the clear disconnect between how non-dominant students are perceived in school and at home. At home, many of these children are resourceful and creative problem-solvers, often responsible for contributing to the household economy. In contrast, at school these same children are often cast in a passive role and occupy the lower echelons in academic subjects (Civil and Andrade 2002). How is competence attributed in everyday life? In school settings? In the STEM disciplinary settings?

Vignette 2: How do task and environment affect engagement?

I met Julián when he was in fifth grade and followed him through sixth grade. He was about a year older than the typical fifth grader, due in part to the many moves that he and his family had experienced. By fifth grade he had attended five different schools (2 in Mexico and 3 in the US). I would describe him as a serious student, attentive, and inquisitive. In a problem-solving session in which the students were working in groups on several problems, the teacher had written the following instructions "(1) demonstrate (how you problem solve your word problem); (2) write an equation; (3) solve; (4) explain your process." One of the problems they had was, "This year Mark saved \$420; last year he only saved \$60. How many times as much money did he save this year than last year?"

I am aware of several issues with this task that one could raise from a mathematics education point of view. For example, I am not sure what the teacher meant by the four instructions she gave. What did she have in mind for "demonstrate" and for "explain your process"? Also, the problem itself is fairly typical of school word problems and is certainly open to critique. But it is not my goal here to elaborate on these issues, since the point of this vignette is to contrast in-school with out-of-school (or rather after-school) settings and how those may influence how students act.

Julián was in a group with two other boys, Armando and Leo. Armando tended to be "off task" and would often say, "I'm lost" presumably as a way to get our attention and come help him. Leo was very quiet and I hardly ever heard him say anything in all the times I visited this classroom. Julián right away took the lead on the problem and decided to solve is as a subtraction problem, even though Armando had suggested division. His suggestion was ignored and Julián wrote $420 - 60 = 360$ (in vertical form). Armando then concluded that that was the answer and that they were done, Julián was concerned about how to address the four steps in the teacher's instructions:

> Julián: I solved it but I didn't demonstrate it… (reading step 3) solve it
> Armando: But we already solved it
> Julián: Yeah, we solved it right here (pointing to step 1 on their chart paper, the subtraction) but how can we demonstrate it?
> Armando: Just say that (and he points to step 1)

But Julián kept on looking at the instructions and at the chart paper, trying to figure out how to address those instructions. As I mentioned earlier, it is not clear what the teacher meant by "demonstrate" and I wonder what students thought about that instruction. Throughout this episode, Julián did not seem to be really looking at the problem. He never went back to see if the answer made sense, nor did he follow Armando's suggestion when he said "division." One could argue that this choice of subtraction made sense in that it may have reflected more his experience when talking about comparing savings, as in "how much more has one saved?" rather than "how many times as much?" But in any case, the three boys never really engaged in talking about the problem and whether the answer matched the question. Julián seemed primarily concerned with following the four steps that the teacher had listed and did not question their meaning or their actual work on the problem.

Julián was also part of an after-school project that we had at that same school. In this after-school setting, we tried to build on students' ideas and experiences, and do so in as much of an "informal" setting as we could, given that we were after all in a school building. An important aspect of the after-school setting was that it was bilingual and that in fact the facilitators (undergraduate and graduate students, as well as post-doctoral fellows and university faculty) encouraged the use of Spanish (and used it themselves) as a way to counter the restrictive language policy in place in schools in Arizona. (In 2000 Arizona voters passed Proposition 203 (English for Children) which severely limits the access to bilingual education for English Language Learners.)

One of the activities was to make a model of the after-school classroom. Julián and one of the facilitators, a post-doctoral fellow with Spanish as his dominant language, had each made their sketches and put some measurements in them. The facilitator was working with another student and Julián casually looked over the facilitator's sketch and inquired about a measurement that was different from his. A conversation in Spanish followed in which Julián challenged the facilitator's drawing and said that he had the wrong measurements for one of the sides: "yes [Julián takes the facilitator's pen and starts drawing on the facilitator's sketch], from here to here [pointing at parts of the sketch and drawing a line], it has to go till here, you didn't draw it correctly; they have to be the same [he then starts pointing to the walls in the classroom], look, they are the same." Julián was confident enough about his own measurements and sketch to point out that the facilitator's sketch was not correct. After this brief exchange, Julián went back to his sketch and continued working on his scale drawing.

Different settings come with different norms and participants may follow these norms or challenge them depending on many factors, including the type of setting (and the consequences of not following the norms) and who the participants are (status and power issues). In both activities, the word problem and the scale drawing, Julián was engaged and wanted to do a "good job." But the nature of the task and the environment seemed to lead to a different form of engagement. I do not want to imply that the classroom setting always led to a certain form of engagement and the after-school setting to a different form. In fact I want to highlight the complexity of what it means to be a learner of mathematics across different contexts. This complexity includes aspects such as the nature of the task, the environment, and the participants involved. In the word problem task, I wonder, how engaging did Julián find that word problem? Was it one more example of a typical school task and hence, Julián focused his engagement on following the teacher's instructions? Did he enjoy the scale drawing task because it connected with his interest in drawing (as reported in an interview)? What is the effect of an after-school environment where facilitators often also participated in the activities, as one more member (as in this case with the facilitator's sketch)?

Vignette 3: What is the role of affect, language, and cognition in different settings?

In the last few years, I have been looking at interactions about mathematics between parents and their children (e.g., Menéndez, Civil and Mariño 2009). Most of the interactions we analyze take place in the context of mathematics workshops for parents and children held at schools. While the content is formal mathematics (in that we engage the participants in fairly typical school mathematics content) and the workshops are in a setting associated with formal learning (a school), there are several characteristics that remind us of more informal, everyday learning sites: the workshops often take place in the school library, in the evening; the interactions involve cross-age groups, parents and children, but also across families since several of them know each other and interact outside the school setting; while the content is school-based, the activities often involve games and puzzles; finally, and most importantly for our context, the dominant language of the workshops is Spanish, in clear contrast with the language of the school that is English.

In Menéndez et al. (2009) we argue that these workshops could be seen as creating a third space (Gutiérrez, Baquedano-López and Tejeda 1999) where aspects of the school practices and of the everyday practices come together in such a way that they may blur the boundary that seems to exist between formal/informal or in-school/out-of-school. This may be particularly worth studying for some non-dominant communities where the contrast formal—informal appears to be more marked. For example, in our case, the language of the home/community was Spanish, but the language of the school was English. Children found themselves using both languages in the interactions in the workshops, as their knowledge of mathematics was primarily attached to English. While during the regular school day, parents who predominantly spoke Spanish might see themselves as outsiders of the school community, in these evening sessions they became insiders since Spanish was the dominant language. The collaboration patterns also reflected a blurring of power/hierarchical positioning, with parents sometimes deferring to their children because they felt they were more familiar with the mathematical content. Yet, children were sometimes caught in their wanting to show respect towards their parents while at the same time wanting to assert their knowledge of mathematics. For example, in a discussion of area and perimeter using pentominoes (shapes made out of five squares), Dania (daughter) and Sonia (her mother) had different answers for the perimeter of one of the pentominoes, the 5×1 rectangle. Dania had found 12 while Sonia (and Juanita, Dania's friend and classmate) said that the perimeter was 4 (they were counting the number of sides instead of finding the perimeter of a 5×1 rectangle, which is 12 units). The exchange went on for a while, with Dania trying to explain to them why the perimeter was 12 units. Dania grew more and more frustrated and turned to one of the researchers as if seeking support and validation:

> Dania (to the researcher): What I did, when she [referring to her mother] said "no," was that I doubled this part; since there is five here [pointing to one of the sides of length 5 in the 5x1 rectangle] and five here [pointing to the other side] and that makes 10, and these ones [the other two sides of the rectangle] here are 12, and she [her mother] told me that I was wrong.

Dania, who was always very respectful towards her mother, appeared uncomfortable probably for at least two reasons. One was the fact that her mother and friend (Juanita) were in disagreement with her (and Juanita and she were usually in agreement and overall successful students in mathematics). The second was the fact that Juanita's and Sonia's approach to finding the perimeter was in clash with what Dania knew and had learned in class. She made statements such as, "why do we do it differently in class?" or "you got me all confused because I learned it differently with the teacher." This section highlights several elements to take into account when looking at the interactions about mathematics involving participants from non-dominant communities: affective elements (mother—child relationship; doing mathematics with your parents), cognitive elements (formal/informal; different levels of schooling with the children often having reached more formal schooling than their parents), linguistic elements (e.g., children spoke both English and Spanish; their mothers were primarily Spanish speakers). What role do these different elements (affective, cognitive, linguistic) play in everyday mathematical practices? In school mathematics?

Bringing the three vignettes together

The three vignettes involved children and adults from non-dominant communities. They all highlight their engagement in mathematical practices. Alberto, although seen as under-achieving in the school setting, was described by his mother as a very capable child who contributed to the family finances through his successful participation in their bakery. Joan Solomon (2003) points out that in order to understand how children may react to experiences that try to bridge home and school, we need "to take into account who they are at home, and who at school" (p. 229). Alberto was a resourceful and creative problem solver at home, while at school he was viewed as a low-achiever and less competent. How do we capitalize on the positive identities that children from non-dominant communities exhibit in their home/community environment, in sharp contrast with the often negative identities schools attribute to them?

Julián was a successful student by school standards and was also a very engaged participant in the after-school setting. The contrasting behavior in the two tasks in his vignette serves to remind us of the need to consider the context in which the practice takes place. Although the mathematical demands in these two tasks were not particularly high for a student like Julián, factors such as the setting (classroom vs. after-school), level of interest (he appeared particularly interested in the scale drawing activity), and nature of interactions (in the classroom vs. in the after-school setting) seemed to play a role in his performance. The case of Julián brings to mind how children (and adults) may perceive doing mathematics in different settings. How much of doing mathematics in school is about following the teacher's instructions? What does doing mathematics look like in a setting where we all engage to work on the task (e.g., the facilitators too)? Do different settings lead to different forms of mathematics? What role does valorization of knowledge play here?

The third vignette gives a glimpse of what interactions among children and their parents may look like when discussing school mathematics. Although the vignette can be interpreted from a formal/in-school point of view, there were several elements in these workshops that are likely to have some resemblance to possible interactions in the home or community. The affective element mother—child was very present, along the lines of what Solomon (2003) describes in her account of parents-children interactions around science activities in the home: "They made the investigation at least partly their own, which rarely happens at school. They spoke easily with their parents and were encouraged, joked with, scolded, or ignored in a manner that clearly seemed familiar to them" (p. 229). Another important element present in Vignette 3 (as well as in Vignette 2 in the after-school setting) is the role of the non-dominant community primary language. Elizabeth Mack et al. (2012) powerfully argue for the importance of the use of Native language in their discussion of informal science education programs in Native communities, "language is culture and culture is language. Education should never take away Native language; it should promote it" (p. 61). I argue that this same principle should apply to all groups of people, and in particular to non-dominant communities such as the ones in the three Vignettes, all involving children (or their parents) who had emigrated from Mexico.

These three vignettes reinforce what Léonie Rennie, Elsa Feher, Lynn Dierking and John Falk (2003) write:

> *Out-of-school learning is strongly socioculturally mediated, so research designs need to offer opportunities to explore social and cultural mediating factors including the role of conversations, social learning networks, cultural dimensions, and the use of groups as well as individuals as the unit of analysis*. (p. 115) (italics in original)

These authors add that much of the work with families has been in museums or other such institutions, "with little work done on how families interact in science-related ways at home" (p. 115). And I would add that we know even less about the everyday practices around STEM with families from non-dominant communities. Much of what I have described up to here is connected to the school setting. That is, I have illustrated aspects of the interplay between in-school and out-of-school settings (e.g., forms of engagement, valorization of knowledge, the role of languages, and so on). But what do we know about the everyday practices of members of non-dominant communities and how may these practices connect to those in STEM disciplines? This was a question that we had as we worked with the funds of knowledge concept with a focus on mathematics. One approach that we took to try to document these practices was through what we called occupational interviews (Civil and Andrade 2002), as I discuss in the next section.

Occupational interviews

When I joined the FKT project and we started looking at this theoretical construct with a focus on mathematics teaching and learning, it became apparent that we needed to get a better understanding of mathematical practices in everyday life. This realization led us to the idea of conducting what we called "occupational interviews." I am aware that these practices are tied to a specific occupation (e.g., welder, mechanic, seamstress), rather than to more general activities that families may engage in their everyday lives. While the mathematics content may relate to specific occupations rather than everyday activities, an important aspect from these interviews is the narrative around the processes of learning and engaging in these occupations. Later in this section, I illustrate relevant implications from these processes for thinking about connections to STEM disciplines.

We interviewed (and in most cases also observed them at their practice) several adults, all of whom were of Mexican origin, working-class, and had limited formal education. The interviews conducted with a seamstress, a mechanic, a carpenter, a welder, and a construction worker revealed a wealth of mathematically rich practices. But in order for us to see the mathematics in these practices, we relied on the analysis that one of the researchers conducted. This researcher had a strong mathematics and engineering background from a formal point of view (i.e., university education), as well as a wealth of personal experience with several of these occupations. He was thus able to make mathematical connections between the two contexts, the domain of formal, academic mathematics and the domain of the practices in the interviews.

But what if the only lens we can bring to the analysis is our formal, academic background in mathematics? Let's recall the teacher I mentioned earlier who said, "if you have too much school mathematics, does it erase our practical mathematics?" I wonder if this was my case as I tried to make sense out of the mathematics embedded in a seamstress' practice (González, Andrade, Civil and Moll 2001). Whether it was my lack of knowledge of the practice of sewing, or my formal mathematical background, or a combination of both of these, I know that I had a difficult time seeing the mathematics in the practice (beyond superficial features). As we discussed the activity of sewing with a group of teachers, one of them, who was an experienced seamstress said, "you do not have to do math; you just measure." This teacher would often mention that as a student, she found the subject of mathematics to be hard. Sewing, on the other hand, was easy to her. It is interesting to note that she did not seem to see mathematics and sewing as having any connections and that "measuring" did not seem to be part of doing mathematics for her. For me (and maybe for this teacher), the problem was more related to what I perceived as an illustration of Millroy's (1992) paradox I alluded to earlier, the difficulty in seeing mathematics in situations that did not look like what I had learned in a formal setting such as school. Thus my question became, how can we "uncover" the mathematics in contexts in which we may have no experience with or may look very different from our background in academic mathematics? Although the individuals interviewed were confident about their knowledge of the practice, they tended to dismiss this knowledge as if there was nothing to it, and in some cases their reactions to their practice being mathematical reminded me of the teacher/seamstress who did not think there was much mathematics (if any) in sewing. In her discussion of why adult learners seek to learn mathematics in formal settings, Roseanne Benn (1997) writes that their motivation is:

> To gain access to the powerful and prestigious discourse of academic mathematics…. They are less interested in building on their own existing everyday mathematical discourses which they feel are not valued in society…. Though able to solve problems, if this is not expressed in the discourse of formal mathematics, it is not valued. (p. 181)

Along similar lines, and adding a gender perspective, Mary Harris (1987) presents us with very telling examples, including one in which she considers "the problem of lagging a right-angled cylindrical pipe in a factory" (p. 28) and writes:

> Why is it that this industrial problem is considered to be inherently mathematical whereas the identical domestic problem, that of the design of the heel of a sock, is not? Dare it be suggested that the reason is that the socks are traditionally knitted by Granny—and nobody expects her to be mathematical. (p. 28)

What are the research implications as we seek to understand the connections between learners' everyday practices and STEM disciplines, particularly for those learners from non-dominant communities (be it based on language, social class, race, ethnicity, gender, etc.)? The learners themselves may not "see" these connections, as the occupational interviews indicate, or they may not value what they do as being mathematical; or also, others, including those from dominant communities, may not value it, as Benn (1997) and Harris (1987) imply.

As I mentioned earlier, there are several accounts of mathematics embedded in practices. These accounts have often been carried out by researchers through ethnographic fieldwork and not by those in the practice itself (e.g., Gerdes 1988). While these accounts are important, particularly in that they can help redefine what counts as mathematics, who does mathematics, and where mathematics is located, I still think that often these accounts are kept separate from the "mainstream" research. For example, did any of the research that looks at mathematics from a cultural point of view influence the development of the Common Core State Standards for Mathematics (National Governors Association Center for Best Practices and Council of Chief State School Officers 2010)? Should it? If we consider what John Falk and Lynn Dierking (2010) write about how most people spend less than 5 percent of their life in formal learning environments (e.g., school), then maybe whether formal education documents such as CCSS make any connections to the informal learning opportunities that take place in 95 % of our life is not that important, because formal learning is such a small part of a person's life. Yet, when it comes to non-dominant communities, does this 5 % seem to carry more weight, because the 95 % is often not recognized or valued? In my analysis of a seamstress' practice, I noted that to make the pattern for a skirt she made a quarter of a circle in such a way that it showed the circle as the locus of all points equidistant from a central point (González et al. 2001). Yet, this seamstress did not have a course in formal geometry, nor did she talk about the circle in these terms.

Similarly, in a project in which we were to develop mathematics materials to use with parents, I tried (unsuccessfully) to engage the project team in considering an approach grounded on funds of knowledge. To illustrate to the project staff what that may look like, I drew on one of our occupational interviews with a construction worker who told the interviewer that to make sure that the foundation for a house was a rectangle, they sometimes used the "rule of 12" to check that the angles are 90°. This means that they use a string marked with 12 equidistant segments and they make a "3, 4, 5" right triangle to make sure that the corners are right angles. As I shared this experience, one of the project members (a mathematician) raised the question as to whether we wanted to reinforce these methods from the past or help the parents understand the mathematics that their children are learning, "the mathematics of the new millennium," as he said. (The "new millennium" is a reference to the timing of that project, as we had just entered a new millennium.)

Much of what I have discussed up to here focuses on the potentially different forms of mathematics embedded in different contexts (e.g., everyday practices, the discipline of mathematics, school mathematics) and on issues around valorization of these different forms of knowledge. As I looked again at the occupational interviews we had conducted, what struck me were the similarities across the different people interviewed in how they talked about their occupation, how they had learned the practice, and how they would teach it to others. Lynn Dierking, John Falk, Léoni Rennie, David Anderson and Kirsten Ellenbogen (2003, p. 110) write in reference to learning in out-of-school settings, "learning is both a process and a product, so we need to investigate the processes of learning as well as the products of learning." Indeed, if I focus on the processes of learning in these occupational interviews, I note the following characteristics among those interviewed (Civil and Andrade 2002):

- They learned through observation, by replicating samples, and by taking them apart when possible.
- They learned by participation in the practice, through interaction with others.
- They took great pride in their work and showed a passion for what they did.
- They indicated desire and persistence as characteristics to becoming good at their practice.
- They mentioned imagination (picturing the product) and communication (with their customers) as factors in their learning of the practice.
- They noted the need to feel challenged as being important in their learning process, as this quote from a seamstress shows (González, Civil, Andrade, and Fonseca 1997, p. 14):

> The more complicated a dress is, the more I like it. If it's easy, I don't like it. I can make a bride's dress from one day to the next. Embroidered and all, I can have it done from one day to the next. If it's easy, I don't like it. It's like making gelatin. I don't make it because it's very easy. So, if you want it, buy the gelatin or make it, but I'm not going to make it…. But a more complicated dress is the one I like most…. I want to see if I can really make it, I want to prove it to myself.

Several of these characteristics are reported in studies on learning by apprenticeship (e.g., Lave 1996) and by participation in a community of learners (e.g., Rogoff 1994). Elsewhere (Civil 2007) I have described challenges and affordances in developing school mathematics experiences that reflect the characteristics of apprenticeship learning in out-of-school settings. Certainly more research in this direction is needed, in particular in teasing out the differences and similarities between the nature of practices in STEM disciplines and STEM-rich practices in the everyday life of non-dominant communities. I elaborate on this point next by presenting several suggestions for further research.

Suggestions for next steps in STEM learning research

If we take learning as a cultural process, involving varied repertoires of practice across learners' everyday lives, what should STEM learning research focus on, particularly in relation to how these everyday practices in non-dominant communities connect with practices in STEM disciplines? This is certainly a complex question. We need more research on the nature of these everyday practices (particularly in non-dominant communities). I mean, the what, the where, the how, the with whom? As Carol Lee, Margaret Beale Spencer, and Vinay Harpalani (2003) write:

> Cultural Modeling calls on researchers and practitioners to examine the students' everyday practices, in their families and peer social networks, directing their attention toward processes of reasoning and habits of mind as well as toward naïve theories and misconceptions that may bear some relationship to a targeted set of specific concepts and strategies in a subject-matter discipline. (p. 8)

We also need to understand better the role of valorization of knowledge particularly as it applies to everyday practices versus practices in STEM disciplines. Terezinha Nunes (1999, p. 38) writes, "it can be concluded that the street or workplace and school socialize learners into different practices that are nevertheless mathematically equivalent, even if they are psychologically and culturally distinct." If we recall the example of the seamstress making a circular skirt, or the example of knitting socks (Harris 1987), although these practices may be found mathematically equivalent to practices in school mathematics, what are the implications of the fact that they are "psychologically and culturally distinct"?

I think that our charge is to go beyond seeing how these everyday practices have mathematics (or science or…) in them and look at the characteristics of engagement in these practices and how those relate to engagement in practices in STEM disciplines. The nature of engagement changes as we saw in vignette 1, in the case of Alberto (home vs. school) or in vignette 2, in the case of Julián (in school and after school). In the occupational interviews, we see the different individuals not only very engaged, but the way they talk about their practice reflects knowledge, pride, enthusiasm, persistence and imagination. How do these characteristics compare to how STEM researchers may talk about their practice?

We need to gain a better understanding of the participation structures, particularly in non-dominant communities. Judit Moschkovich (1999) points out that we do not know enough about the participation structures in the home cultures of Latino students in our local contexts. Language is a key element of the participation structures. What language(s) people choose to speak, when and how, should be taken into account as we try to understand, for example, interactions around mathematics, as illustrated in Vignette 3. This vignette also gives a very brief glimpse of what is another area for further research, namely the potential of the concept of third space to examine the interplay between everyday STEM practices in non-dominant communities and the practices in STEM disciplines. Much of the research based on a third space is in connection with bridging out-of-school and in-school ways of knowing and learning (particularly with non-dominant students) (e.g., Gutiérrez et al. 1999). Na'ilah Suad Nasir, Ann Rosebery, Beth Warren, and Carol Lee (2006) point to some research that "explores intersections between everyday practices and important disciplinary knowledge" (p. 493), but still, I argue that most of the examples are seen within the school lens. However, I want to note that they write:

> In order to see robust, authentic connections between the everyday knowledge and practices of youth from nondominant groups and those of academic disciplines, we must look beyond the typical connections made in school curricula and identify important continuities of practice. (p. 495)

It is this looking beyond school that I am arguing for. Elizabeth Moje, Tehani Collazo, Rosario Carrillo and Ronald Marx. (2001) refer to the existence of at least three kinds of Discourses in the classroom:

> Although several different intersecting Discourses can be at work in any one classroom, at least three are particularly salient for this discussion: disciplinary or content area, classroom, and social or everyday Discourses. These Discourses represent distinct ways of knowing, doing, talking, reading, and writing, and yet they overlap and inform one another in important ways. (p. 471)

Where might this work take us if we move away from the classroom context and look at the disciplinary and the everyday Discourses?

Finally, underlying the different areas of suggested research (nature of everyday STEM practices, valorization of knowledge, different forms of engagement, participation structures, interaction, language choice, and third space) is the notion of power. In her work on ethnomathematics and its possible relationships to school mathematics, Gelsa Knijnik (2004) writes about the need to examine the power relations that go hand in hand with the different forms of mathematics. Building on this, I argue that we need to examine the role of power relations across the different settings in which STEM learning takes place (in everyday life; in school; in the STEM disciplines). I close with the voices of three Latina women whose messages underscore the need to address power issues as we look at the future of STEM learning research. The three quotes come from reflections from participants in parental engagement projects in mathematics that were grounded in critical education principles.

> No one is going to mandate that is has to be the way they say, because we also think and solve problems.

> It is important that we as parents have these types of [mathematical] discussions. We also realize that though we may not have a certificate in hand, we are also teachers. My fear slowly went away and I learned that your voice counts, even if you don't speak the same language, your voice counts.

Acknowledgments I would like to thank the reviewers for their very insightful comments and helpful suggestions. The research reported here was funded in part by The National Center for Research on Cultural Diversity and Second Language Learning and by the Center for Research on Education, Diversity & Excellence (CREDE), through the Office of Educational Research and Improvement (OERI) of the U.S. Department of Education, under Cooperative Agreement No. R117G10022 and PR/Award No. R306A6000 (for Funds of Knowledge for Teaching project and project Bridge); as well as by the National Science Foundation, grant ESI-0424983 (for CEMELA (Center for the Mathematics Education of Latinos/as)). The views expressed here are those of the author and do not necessarily reflect the views of the funding agencies.

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