Building on Community Knowledge:

An Avenue to Equity in Mathematics Education

Marta Civil

The University of Arizona
Department of Mathematics
617 N. Santa Rita
Tucson, AZ 85721

A shorter version of this paper will appear in N. Nassir. and P. Cobb (Eds.) *Diversity, Equity, and Access to Mathematical Ideas*. Teachers College Press

This paper presents my personal reflection on over more than a decade of work in mathematics education in low-income, mostly Latino communities in Tucson. My research is driven by an equity agenda that capitalizes on building on the students' and their families' knowledge and experiences as resources for schooling. What are the implications for the mathematical education of these children, if we take their experiences and backgrounds as resources for learning in the classroom? This paper addresses this question by paying special attention to the challenges in the pedagogical transformation of household knowledge into mathematical knowledge for the classroom. These challenges are related in part to teachers', students' and our own beliefs about what counts as mathematics. Most of my focus in this paper is on a critical reflection on our own work as we tried to link school mathematics with everyday experiences. I will use examples from the different modules / teaching innovations we carried out during the years to examine two aspects of our work:

a. Developing teaching innovations in mathematics that build on cultural aspects of the students' community/ies (e.g.. how do our values about what we consider to be mathematics influence the curriculum development? (Civil & Andrade, 2002)).
b. Implementing such innovations with an eye on the mathematics (e.g., what resources and support mechanisms are needed for teachers to successfully carry out the implementation?).

Background: Setting the Context

Much of the work[1] I describe in this paper originated with my involvement in the Funds of Knowledge for Teaching project (FKT) (González, 1995; Moll, 1992; Moll, Amanti, Neff, & González, 1992), which was followed up by project Bridge, which had a specific focus on mathematics (Civil & Andrade, 2002). These projects were collaborative research efforts between university researchers and elementary school teachers. The teachers worked in schools in working-class / low-income neighborhoods where the student body is largely composed of ethnic and language “minority” children. FKT is grounded on the theory that household and community knowledge can provide strategic resources for classroom practice. It is assumed that all households have historically accumulated and culturally developed bodies of knowledge and skills on which they draw for daily survival and well being (Moll & Greenberg, 1990). As González (1996) writes, “this assumption is critical in terms of re-conceptualizing households, not as the source of barriers to educational attainment, but as repositories of resources that can be strategically tapped” (p. 3). Within the FKT project, instead of relying on a static, bounded definition of culture, teacher-researchers learned firsthand about the lived realities of students and their families, and then used this knowledge as the basis for curricular units within the classroom (González, 1995). Through ethnographic household visits, teachers learned about the labor and social history of some of their students' families as well as about their views on education, and about the children's daily activities and chores. Through these visits and conversations, teachers uncovered that many of these families have an extensive knowledge about construction, repairs, carpentry, household management, folk medicine, farming. Teacher-researchers and university researchers met regularly (usually every two or three weeks) in study group settings, to discuss the findings from the household visits and to brainstorm curricular implications that often led to learning modules that were implemented in the classrooms.

When I joined the project, a core group of teachers and university researchers had been collaborating for at least two years. I sensed that some of these teachers wondered why a mathematics educator would be interested in this project. Why indeed? I was (and still am!) particularly intrigued by studies on everyday cognition, in-school mathematics / out-of – school mathematics, ethnomathematics (Abreu, 1995; Bishop, 1994; Brown, Collins, & Duguid, 1989; Lave, 1988, 1992; Nunes, Schliemann, & Carraher, 1993). I was puzzled by research that pointed to different levels of performance on mathematically "similar" tasks and to issues of transfer across contexts. At a practice-based level, I was concerned by the differences in achievement (as measured by school / formal education standards) among preservice elementary teachers in mathematics content courses. It seemed that those who were trying the hardest to make sense of mathematics by connecting it to their world and their everyday life activities were often among the ones feeling that they were not good at mathematics (Civil, 2002a). Abreu's (1995) research on the different valorizations given to home and school mathematics, and the differences in performance in school mathematics among children who were actively engaged in home mathematics (e.g., related to sugar cane farming) and those who were not, has been particularly influential in my thinking. Lave (1992) writes about the conflict between in-school and out-of-school knowledge, "the implication to children is that everyday experience is to be valued negatively" (p. 78).

I was instantly attracted to the FKT project because of its anthropological component (that to me connected with my interest in ethnomathematics) and because of its practice-base orientation in which teacher-researchers and university researchers were jointly seeking ways to bridge the gap between in-school and out-of-school experiences. But, what attracted me the most was the project's emphasis on the education of low-income, language and ethnic "minority" children. I wondered, what would it be like to develop teaching innovations in mathematics that build on these children's and their families' backgrounds and experiences?

When I joined FKT, several teachers acknowledged that while they were comfortable using a holistic and integrated approach to most content areas, they often found themselves following a rather traditional, by the book approach when it came to their teaching of mathematics. As one of the most veteran Funds of Knowledge teachers said, "I know how to let students play with language but I don't know how to let them play with mathematics."

In the next sections I use excerpts from some of the modules that we developed with a particular eye on the mathematics, to address the questions I have raised so far. I do this by framing the sections in terms of two related questions: Where is the mathematics? What does a "successful" implementation look like? First, I summarize the vision I had in mind for a teaching innovation that would be both mathematically rich and community-based (see Civil, 2002, for more on this vision). What do I mean by "mathematically rich"? I was looking for situations in which students would engage in what one could consider "mathematics for the sake of mathematics" – for example, problem-solving situations that call for different approaches, tasks that require offering a mathematical justification, activities that cut across different areas of mathematics (to highlight the connections). Yet, at the same time, I wanted the mathematics to be connected to community knowledge. This, as the rest of the paper will illustrate, means two things: I was interested in activities that grew out of the community knowledge and experiences (such as the construction or the garden modules I will describe) and I wanted to capture the forms of knowledge that we had seen in these communities, in particular the idea of apprenticeship learning. The FKT project had gathered evidence that at home and in their community, children were often active participants in the functioning of the household (e.g., language interpreters for parents and other relatives; assisting in the child care of younger siblings; helping out in the economical development of the household (e.g., helping in the repair of appliances, cars); playing an active role in traditional ceremonies (e.g., Yoeme Easter)). This active participation and the learning that accompanies it, which reminds me of learning by apprenticeship, is quite different from what many of these students experienced in their traditional schooling (see Civil & Andrade, 2002, for the concept of transitions between home and school mathematics). So, I wondered, what may the learning environment look like if we were to develop a more participatory approach towards the learning of mathematics (similar to what these children experience in their out-of-school lives)?

Where is the mathematics?

One of the first modules in which I played a role centered on the topic of money and involved a third grade and a fifth grade teacher at the same school (see Civil 1992, for a detailed account of this module). At a study group meeting, the fifth grade teacher reported that one of the students whose house she had visited had shared with her his collection of foreign coins. Furthermore, she knew that many of her students were familiar with at least two types of currency (US and Mexican), through their frequent trips across the border to visit relatives. This led to her idea of developing a learning module around the theme of money. The third grade teacher expressed an interest in jointly developing this module. In subsequent planning meetings, some of the mathematical ideas that we came up with were:

- Use the students' familiarity with money to further their learning of arithmetic with whole numbers (for the third graders) and with decimal numbers (for the fifth graders).

- Work on ratio and proportion through price comparison situations, arising from the children's experiences.

- Create a currency for each of the two classrooms, make products to sell ("cascarones"[2] in the fifth grade class; paper flowers in the third class) and have a commercial exchange between the two classrooms. This would lead to work on currency exchange problems.

The two teachers and I held several planning meetings brainstorming the ideas above and how to implement them. But what really happened in each of the classrooms was quite different from what I had envisioned or expected. Although some of these ideas were present in the activities, overall the money module focused on children discussing social issues in relation to money (such as welfare, food stamps, buying a car, a house) in the third grade class and on researching topics such as "money, power, and politics" or "foreign currencies", in the fifth grade class. Hence, in this class, the main academic areas emphasized through this module were social studies, reading and writing. In the third grade class, mathematics was more present, for example through connections to children's literature that had money as the focus. But even with the third graders, I think that we only scratched the surface of the mathematics in a module around money. The very rich discussions in both classrooms showed the wealth of knowledge that these children had about everyday uses of money, budgeting, and what it means not to have enough money. Yet, in terms of our mathematical agenda, I did not feel we succeeded in exploring the potential in this module. Why? In my mind there were several reasons, some of which we have encountered in this and similar projects and have to do with the difficulties of developing sustained learning and teaching environments that are compatible with the structure of the school day and of schooling in general. In the case of the money module, it took part towards the end of the school year; constant "distractions" (field trips; going to the auditorium to see a play, a dance, a concert; testing; half-days) that are typical of school life and in many cases quite valuable, but that seem to become more frequent as the end of the year approaches, made us constantly revise our plans. But perhaps the main reason for so little mathematics in the module was lack of time and our lack of experience working together in a content area such as mathematics. I was a newcomer to the project and this was the first time that we were working on developing modules that would have a special focus on mathematics. A key aspect of the development of learning modules in the FKT project seemed to be to start with the children's ideas and knowledge and build from there. This strategy worked well for the teachers in the project to encourage writing and reading starting with topics that the students are interested in. In fact, this was the case in the fifth grade class: the students took very seriously their research projects on themes such as Money, Power, and Politics; Foreign currency; How our money is spent--budgets. We wanted to do the same thing for mathematics, that is bring it in as we saw it relevant to what the students were working on. Yet, this was difficult. As the third grade teacher said in an interview reflecting on our attempts to bring in the mathematics in the money module,

> I am very aware of my lack of knowledge in math education, period. And I think that's what inhibited me, not allow me to carry it further, but yet the philosophies are parallel [this is in reference to a prior discussion comparing approaches to the teaching of literacy and the teaching of "reform-based" mathematics], and that's important to realize that. So, now that I understand that the philosophies are really parallel, that learning occurs when it's authentic, when it has something to do in the child's life at that point in time (…) and I think that's very important in both the literacy and the mathematics, but I had more training on how to do this in literacy and I have not had the training on how to do that in mathematics. (…) So, when you came in, that was the support, the source that I could tap. (…) When P. [the fifth grade teacher] and I met informally to discuss it, again most of the discussion was on literacy, we both felt we had more expertise in that area; on the mathematics, it was "well, let me ask Marta, let's see what Marta does." And you had to be there for us to even think about these issues.

Our lack of experience working together meant a constant exploration of what our different ideas and goals were in learning mathematics. This was a collaboration project between teacher-researchers and university researchers. My role was not to present them with a plan of action. The fact that most teachers in the project were more comfortable and had more experience trying innovations in literacy than in mathematics is a key point. What I realized was that teachers needed to have a chance to experience for themselves what "playing with mathematics" may be like. Although "superficial" uses of mathematics may be easily available (counting, measuring, simple arithmetic...), other features of mathematics, such as reasoning, abstracting, generalizing, using the language of mathematics, may be more elusive and hard to make them emerge from the context. I will come back to some of these dilemmas in the closing of this section. Next, I present one more example of a learning module that brings up a somewhat different yet related issue and thus sheds more light on some of the dilemmas.

<u>Preserving the purity of the Funds of Knowledge</u>

In this next module, the teacher (a second grade teacher in an elementary school just outside a Native American (Yoeme) reservation) wanted to emphasize mathematics. The theme for the module was construction. The teacher had conducted household visits the year before (when her students were in first grade; she stayed with them for second grade) and had realized the wealth of knowledge about construction that existed in most families. To plan for the module, the teacher and three university-based researchers (including myself) met several times during the month of July (school starts in August). The meetings ranged over a variety of topics: how to integrate the different content areas while keeping in mind the required curriculum, how to assess the children's learning, how to bring in the knowledge from the home (e.g., whom to invite as guest speaker and when). We have described many aspects of this module elsewhere (Civil, 1993; 2002a; Sandoval-Taylor, in press). The construction module provided quite a few opportunities for the children to engage in rich mathematics particularly in relation to patterns, measurement, estimation, and properties of different shapes. Arithmetic was used in context and I witnessed children coming up with a variety of different ways to add and subtract numbers. The measuring activities led to some of the difficulties that children this age encounter when using a ruler (such as where to start reading the ruler and how to read a result that does not end in a whole number). Since these students were used to working with each other and to comparing ideas, they naturally engaged in dialogues about their different interpretations on how to use the ruler. These children were persistent and seemed eager to explore a question and engage in conversation about their work with me or any other adult who visited the classroom. On any given day, they were either constructing something, or trying to guess someone else's pattern, or working on a problem, or talking to their partner about the task, or writing in their mathematics journal. In Civil (2002a) I discuss some of the mathematics in the module. Here, I want to focus on only one aspect of our work--what I view as a possible tension that I describe as "preserving the purity of the funds of knowledge, perhaps at the expense of mathematics." The teacher wanted her students to have ownership of their learning. A key issue was that the opportunities for mathematical exploration had to arise from the children's and their families' experiences. This was consistent with her view that "there is a lot that they know about mathematics, everything you do is mathematics." In Sandoval-Taylor (in press), she writes,

> I wanted the module to be inquiry-based, focused on my students' prior knowledge, and I also wanted the children to make the decisions and negotiate the curriculum. (p. 224) (…)
>
> For example, if a parent visited the class and brought up estimating how many nails are needed for a certain task, I wanted to be able to follow this with a mini-lesson on estimation. The parent would provide the focus and the set would already be there for this lesson. (p. 230)

This teacher was a firm believer in parents as resources. To me, this concept of resources, as reflected in the excerpt below, relates closely to the notion of parents as intellectual resources (Civil & Andrade, 2003), which I will come back to at the end of this paper. In reflecting on how to assess children's learning in this module, she writes,

> I was satisfied with the assessment procedure but still felt that parents would contribute additional knowledge that would help students on the post-test and I wanted to reflect this in the assessment task. I knew students would grow when parents came in and particularly when students used them as resources to answer their own questions. (p. 232)

During the planning meetings that we held prior to the module implementation, we went back and forth on the issue of assessment. We soon reached agreement on one possible task to give the students. We asked them "how do you build a house?" We chose six students to be individually interviewed (pre and post) and the rest of the children answered this question in writing (pre and post too). A comparison of the pre and post interviews as well as of the pre and post write-ups showed clear growth in terms of literacy and general knowledge about how to build a house. Our dilemma during the planning meetings was on how to assess the children's mathematical learning. What kind of task could we give them (as a pre and post) that would preserve the purity of the funds of knowledge? In order for us to respect the teacher's beliefs in building on the children's and the families' knowledge (e.g., as the quote earlier on when an estimation lesson may occur, or on how parents are likely to contribute knowledge that should then be reflected in the assessment), we had to plan for different possibilities, while knowing that everything may change depending on how the module evolved. I, on the other hand, wanted to make sure that we had in place what I thought would be a mathematically rich task. At one of the planning meetings, I suggested that a possible activity could involve the children making something (e.g., a chair) for a doll or an action figure. This would allow us to discuss proportional reasoning. Then as a post-test, students could make something else for that doll/action figure. In reflecting over this same issue, Sandoval-Taylor (in press) writes,

> [The author has just summarized my idea for assessment] I was not sure that learning about proportion would emerge during the unit. From my experiences in my students' community, I thought that the unit focus would more likely be on constructing buildings. I thought this might be a better focus for an assessment prompt. Students could be asked, for instance, how to build an additional room on their homes. (p. 231)

In reflecting back on this module and in particular on this assessment issue, I am not sure how mathematically appropriate the proportional reasoning task that I had in mind would be for second graders. I remember me saying that it would probably have to be adapted, as I had only tried it with older children. But what caught my attention is that we never really discussed the appropriateness of the mathematical content but rather, our discussion revolved around whether making furniture (as in my example of the chair) and engaging in proportional reasoning tasks would be something that would naturally emerge from the module. If it was not grounded directly on the Funds of Knowledge pertinent to this classroom, did we want to pursue it? In the excerpt above, the teacher suggests "how to build an additional room on their homes" as a more appropriate assessment prompt. But then my question would be, "where is the mathematics?" I am not denying that in building an additional room one uses mathematics, but would we be able to uncover it in asking children this question? Maybe my hesitations are the result of my content orientation. For example, I would have liked to see how these children tackled problem-solving type situations, investigations in mathematics. The teacher and I talked about this, but my impression at the time was that she viewed these mathematics tasks as artificial and removed from the children's experiences. This potential tension between developing mathematics activities that reflected the funds of knowledge vs. activities that would be more along the lines of mathematicians' mathematics (see Civil, 2002b, for a discussion on different forms of mathematics) was not unique to the construction module. For example, in the money module I described earlier, I thought that presenting the students with problem-solving situations involving looking for combinations of coins might be a rich mathematical experience. But what connection to home knowledge does this task have?

The two examples presented so far show some of the dilemmas with infusing the modules with what in my view would be rich mathematical tasks. Whether it was because these teachers had not had the same chance to play with mathematics as they had had with language, or whether it was because they believed in anchoring the mathematics in the funds of knowledge, or whether it was because I could not see mathematics beyond my academic training, I could not help but wonder "where is the mathematics?" "Did we do enough or did we just give superficial uses of mathematics?" These questions mostly relate to the teachers' and my views about what counts as mathematics and what it means to teach within a funds of knowledge perspective. But what about the students' views? The next section addresses this.

What is doing mathematics in school?

After the year of the money module, the fifth grade teacher moved to a different school. For the next two years, another researcher and I collaborated with this teacher. She was particularly interested in strengthening her students' mathematical knowledge to help them succeed in their transition to middle school. We developed several modules including a revised version of the money one. Our agenda was to advance these students' learning of mathematics. We took a slightly different interpretation from the approach in the FKT project as we tried to ground the modules on the children's interests and experiences (rather than on their families, even though the teacher did conduct household visits). We put particular emphasis on other aspects of the FKT pedagogy, namely, inquiry-based learning and a participatory approach to instruction. As we tried to develop these approaches to mathematics instruction, in which we wanted to encourage students' sharing of ideas, we encountered several obstacles. At this school, by the time children reached fifth grade, many of them had been together since Kindergarten. Friendships and rivalries were well in place. Furthermore, the teacher was a newcomer to this school in which many of the teachers and staff had been there for years and had formed a close-knit community (see Civil, 2002b, for more details on the setting). These students were not used to engaging in discussions in mathematics. The teacher describes the situation quite clearly in the quote below:

> They didn't see the point of the discussion; they didn't like waiting on everybody to talk. You know, you have to have waiting time. A lot of the kids were very impatient about giving waiting time to their colleagues. They didn't feel like that was work. To them, work is filling out worksheets and turning the

> paper in and seeing if they got it right or wrong. So, hopefully this project little by little is helping them rethink what, you know, is work, when has work been done, what tasks are really important, and what tasks aren't. [Teacher's interview]

Our biggest struggle was in relation to our efforts to change the social and sociomathematical norms (Yackel & Cobb, 1996) in these classrooms. I have addressed this as well as issues related to opening the patterns of participation in one of these classrooms elsewhere (Civil, 2002b; Civil & Planas, 2004). But a related issue to that of sociomathematical norms, are students' beliefs about what they were willing to view as valid mathematics. As the teacher's excerpt above shows, these students were expecting a worksheet approach to mathematics teaching and learning. Our attempts to engage students in, for example, discussing the uses of mathematics in everyday life and in different occupations, or working in small groups on problem-solving type tasks, were often met by resistance and even questions about what this had to do with doing mathematics. I know this is no surprise to anyone who has tried to develop a teaching innovation. My concern is with whether students viewed the mathematics embedded in the modules as "real" mathematics. By fifth grade, students have developed an idea of what to expect in school mathematics. Experiences such as the FKT project are often limited to a few teachers in different schools. So, after one year in a classroom where teacher and students try to base the learning of mathematics (and of other subject areas) on their everyday experiences and knowledge, these students usually move to a very different kind of classroom for the next grade. Students may have indeed been involved in rich mathematical opportunities but if they do not see what they did as valid mathematics are we helping these children?

<u>Dilemmas associated with "where is the mathematics?"</u>

I have presented some of the dilemmas and even tensions that I experienced as we tried to develop and implement learning experiences in mathematics that build on students' and their families' backgrounds and knowledge. The overarching theme characterizing these dilemmas is the issue of beliefs and values about mathematics and about its teaching and learning. The construction module teacher had a firm belief in grounding the experiences on the families' knowledge, hence was reluctant to use tasks that may not relate directly to those experiences. In the money module, the teachers were more comfortable with a participatory pedagogy in language than in mathematics. As one of them said, she did not know how to let her students play with mathematics. In the fifth grade experience, where the emphasis was more on the kind of mathematics that I was aiming for, the students resisted some of the innovations as they did not seem to fit their views and expectations for school mathematics. Underlying these dilemmas are also my own beliefs about mathematics. As we tried to uncover the mathematical Funds of Knowledge through household visits and occupational interviews (Civil & Andrade, 2002), I realized how limiting my own training in academic mathematics seemed to be for this endeavor. Millroy's (1992) paradox rings particularly true for me, "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?"(p. 11) I knew what I did not want: superficial applications of "household" experiences. Although I believe in the pedagogical approach behind contextualized / thematic instruction, I am concerned that often the mathematics in those themes is "watered" down. It is not challenging students' thinking in mathematics. After over a decade of work in this area, I am still left wondering about the process of pedagogical transformation of mathematical funds of knowledge for classroom implementation (see González, Andrade, Civil, & Moll, 2001, for a discussion of this issue). In the next section, I present one example of what in my view was a "successful" (in terms of what I was looking for in mathematics) implementation.

What does a "successful" implementation look like?

Throughout both the FKT and the Bridge projects, the household visits and observations had consistently revealed a "learning by participation" approach to assist children in their acquisition of the necessary skills for the tasks at hand. I have always been intrigued by the possibilities of bringing such model of learning to the school setting, particularly in mathematics. In writing about learning by apprenticeship, Lave (1996) says,

> I have come to the conclusion that the "informal" practices through which learning occurs in apprenticeship are so powerful and robust that this raises questions about the efficacy of standard "formal" educational practices in schools rather than the other way around. (p. 150)

Both Lave (1996) and Rogoff (1994) write about the concept of learning as changing participation in a community of practice. Rogoff writes, "learning and development occur as people participate in the socio-cultural activities in their community…. Learning is a process of *transformation of participation* itself" (p. 209). She then discusses three models of teaching and learning: transmission, acquisition, and participation. The first two are characteristic of schooling. In the transmission model, knowledge from others is passed on to the learner (adult-centered) and in the acquisition model, the learner discovers the knowledge on her or his own (child-centered). In the participation model, the learner participates in a community of learners. In this model, learning takes places through collaboration and engagement in activities that are important to the practices of the community. To a certain extent the construction module and the example I present next (the garden module) show attempts to recreate this participation model in the school. Furthermore, the garden module also reflects our attempts to develop a mathematical apprenticeship in a school setting (van Oers, 1996), by embedding the mathematical learning in the "context of a sociocultural activity in which the pupils want to participate and in which they are able to participate given their actual abilities" (p. 104).

The example takes place in a fourth/fifth grade combination classroom. The teacher, Leslie, had been with the fifth graders since the year before. She was used to having parent come to her classroom and contribute their expertise. So, to her, this idea of building on parents' and community knowledge was not new. She viewed this approach as fundamental towards the development of a sense of community in her classroom. What was new for Leslie was the development of a learning module that would focus on mathematics. In fact, she had joined project Bridge as a means to further her own understanding of mathematics.

The garden module

This module grew out of a special extended study group session that we usually held in the spring. This session was a whole day retreat in which we all brainstormed possible curriculum modules grounded on the findings from the household visits. Two of the teachers had uncovered funds of knowledge related to gardening within the families they had interviewed and decided that they wanted to develop a module around gardening. Hence, part of the retreat time was spent working as a group on what a garden module would look like and in particular what may be the mathematics opportunities in such a module. Leslie had made it very clear that her interest in the overall research project was to explore how "rigorous mathematics could be developed from household visits." I recently asked Leslie what she meant by this,

> At the time I was into finding a real connection between what the households offered and what we at school were offering. There often was not an intersect that made sense to me. Yes, I saw the sewing and carpentry and swap meet issues and believed all of them involved math, but also a lot of them could be trial and error… So, my interest was in taking something that originated from the household interview and using that to develop math content…. The question of rigor came up when I was looking for where in the curriculum and where in math as a field would anything having to do with gardening intersect? … Rigorous math to me implies that it can be connected to math at large, in this case area and perimeter evolved as the math most closely connected to something the students would experience in a more abstract way in middle school. [e-mail communication]

Thus, Leslie and I started our collaboration with the goal of exploring whether rigorous mathematics could be developed from the household. To me this was an intriguing prospect because on one hand, Leslie shared much in common with the second grade teacher in the construction module (discussed earlier in this paper), in that she wanted the children to guide the curriculum. On the other hand, she wanted to make sure that we addressed key concepts in mathematics in her grade levels (fourth and fifth). Although the two objectives are not incompatible, my experience so far had been that the mathematics had not been as strong as I would have liked it, in part for the reasons discussed earlier in this paper. The garden module in a sense gave me the feeling that we finally "got it." By this I mean that we were able to build on the gardening experiences that the children had throughout the module to engage them in mathematically rich tasks (e.g., exploring how area varies given a fixed perimeter; discussing different ways to graph the growth of an Amaryllis, which included the concept of scale). We have described this project in detail in Civil & Kahn, 2001 (this piece has an emphasis on the mathematics) and in Kahn & Civil, 2001 (this one has an emphasis on the development of the overall module). Here my focus will be on the teacher's reflection on some aspects of the module, in particular her comments about involving the parents, as well as on some considerations related to building on everyday experiences.

The families were involved in many aspects of this module, from contributing actual resources (such as seeds and soil) to contributing their expertise with gardening. Leslie was also very knowledgeable about gardening. Thus, she was able to bring her own funds of knowledge to the module. To better describe the kind of environment that Leslie was working with, I am including here an excerpt from her journal. This is from the beginning of the school year when she introduced the project to the parents at the open house. Throughout the whole project Leslie would e-mail me journal entries quite regularly. In this excerpt Leslie is telling me what she told the parents and what the reaction was.

> I asked your kids to reflect on themselves as learners, because I want them to think about themselves and how they can grow as learners, but more importantly as people. In the elementary school we have a chance to impact on the kids and create a community. Once the kids reach middle school it becomes more difficult so we want to establish school as a big part of what they consider their community, part of that is caring about themselves and others as well. I want the kids to think for themselves and be challenged as thinkers. In order to do that I have to engage the kids directly in their education, which brings me to the next part of this talk. If you look around the room you'll see a lot of information about the Navajos and other nations. We have weavings and small displays. (…) We talked about the way the Native Americans and other indigenous people colored their yarn. From there we decided that maybe we could try and garden here in the desert and figure out how to make colors as part of our challenge. And this is where you come in. Your kids are going to be coming home and asking for all sorts of stuff, even horse manure and I want you to think about what they are saying, but not discourage them. Here is where the higher order thinking skills come in. Some of the things they are going to want to try won't work and that is ok because part of the art of reflecting is thinking about what didn't work and starting a second generation of the same idea. I am also fortunate to have some

> university people helping me look at the math in this project. [End of section on what Leslie told the parents]
>
> As the parents were milling about the room, they came up to me and offered these things to help: penpals with cousins who teach in Tuba City [hence a connection to the Navajo world]; a chart of how the Native Americans actually made the dyes: advice that geraniums will sprout in soil, offers of donations for pots, chicken wire, and tubing for irrigation. What I am saying is that every parent that was there supported the project and can be counted on the help when I ask for it. [September 9]

A couple of days later, she wrote

> What I am really saying is that because I have taken the risk to ask parents to help with a real inquiry project they are rallying around me. This is not something that I pull out of my file cabinet every year in September. Having never done this before I have only some idea of where it is going. The parents know this and they are creating the curriculum within my frame. It is very exciting. And frankly I am hard to excite.

Leslie was an experienced teacher (about 20 years in that school district) who had been at that school for five years. She was well liked and respected by the parents and most likely this helped them give her a vote of confidence when she decided to try something different from the previous years. Certainly we have to wonder what may have happened had she been in a different environment. Here, she drew the parents in; they became co-constructors of the curriculum. This is a very different view from typical parental involvement. In my view, Leslie went beyond the household visits. She not only learned from the parents / families and then had some of them come in as experts, but she actually dialogued with many of them and those dialogues helped her shape the curriculum. This is one more aspect of seeing parents as intellectual resources.

<u>A look at some of the mathematics in the garden project</u>. Our focus was on the mathematics and this was maintained throughout the module. Leslie and I shared a common goal: can we

combine everyday mathematics and academic mathematics (Civil, 2002b)? For example, as the plants grew and the children refused to thin them or to get rid of some of them, we needed bigger gardens. Each group of 4 or 5 children had a garden enclosed with chicken wire. How could we make those gardens bigger without adding any more chicken wire? From the point of view of an out-of-school problem, one could argue that the mathematics is limited: by just pulling here and there on the chicken wire, the different groups were able to make their enclosures bigger. In doing this, most gardens ended up in a somewhat square /circle shape. But we did not think that this would be enough to make the mathematical connection. So we actually developed an artificial activity: the making of a garden enclosure using a 3 feet long string that each student glued to paper in any shape that they wanted to make. The challenge then became to find the area of that shape (students had different tools around, including cubes and tiles to cover the area and then count, as well as rulers). The different shapes with their area were displayed and a discussion of what shape would give the largest area followed. Because the activity was grounded on their experiences with the garden, we believe that despite its artificiality, the students were intrigued and curious about the problems of how to find the area of an irregular shape and how to maximize the area while keeping the perimeter fixed (see Civil & Kahn, 2001, for examples of children's thinking on these tasks). The students' experience with the in-class activity made its way into their gardens. As the need for bigger gardens continued, many of the groups started working towards making their garden circular (although some children realized that a circular design could be problematic in terms of access to their plants). Upon reflecting on this experience, Leslie wrote:

> Each time I asked them what shape they wanted and to trace it on the dirt or use rocks for an outline, they chose a shape close to a circle. Except one group who wanted to stay next to another group,

> cousins in real life, who made a very long triangle. One group moved from a circle to an oval because their circle was so large that they would not have been able to reach the plants in the middle. [1/15]

The idea of grounding in-school mathematics activities on everyday experiences is not unproblematic. For example, once the out-of-school activity is brought into the school, it may loose its appeal or as Schliemann (1995) writes,

> To bring to the classroom problems that can be related to their everyday practice does not seem to be the answer since these will also be limited and will not help exploring new facets of mathematical knowledge which are not part of everyday situations. Moreover, once transposed to the classroom cultural setting the problem is no more the same. (p. 57)

The garden project gave us an indication of a potential interference between everyday experiences and school mathematics. At the end of the year I conducted task-based interviews with four students (two fourth graders and two fifth graders) to gain some perspective on these four children's views on the garden project, as well as to assess some aspects of their mathematics learning. One of the tasks involved revisiting finding the area of an irregular shape (a "garden" made with 1-foot string) and discussing what shape would have the largest area (given this perimeter). One of the students kept going back and forth between whether the garden with largest area would be a circle or a square. His reasoning was based on the shape of the pots. Since the pots for the real garden were circular, he argued that a circle would be the best shape; but for the one in class (as well as during the interview), which used square tiles as the "pots," he argued that a square would be a better shape because "I think that it would have to be like a square this way, to hold more because they are square units. Because, I mean you can't cut a plant holder in half… I mean you can fit circles into squares, but it is hard to fit a square into a circle."

Another student, who was also undecided between a circle and a square for larger area, leaned towards a circle as the one having the largest area but in practice (i.e., in real life) she seemed to prefer a square. Below is an excerpt from the interview on this topic (K is the student):

> M: Ok, so do you think if you have to choose between a circle and a square do you think it will make a difference or would you choose actually, one of them?
>
> K: I would choose square.
>
> M: You would choose a square. And why would you choose a square?
>
> K: Um, it looks… then you can put it in rows.
>
> M: OK so I see. So...
>
> K: In the garden we had to put rows. With a circle you have to maybe put them around it like that in a spiral sort of. (…)
>
> K: it [the square] is easier to work with.

In my view, these two students were using practical reasoning to justify their answers. They seemed to understand that in real life other factors may have to be taken into account. Whether it was the shape of the pots or issues of access to the center of the garden (rows vs. spiraling), these students were making connections to the reality they had experienced through the garden project in their assessment of what was the most efficient shape. These two students, however, were also able to play the school game and explain why a circle would have the largest area. But I wonder about the possibility of other students bringing in the real life experiences to bearing in school settings and not knowing how to play the school game, hence saying that a square would be the best shape (even though the "expected" answer is a circle). The research by Cooper and Dunne (2000) illustrates some of the problems that may occur when children (particularly working class children in their study) try to "import their everyday knowledge when it is 'inappropriate' to do so" (p. 43).

The garden project was a learning ground not only for the students but also for the teacher and for me. For example, Leslie had prior knowledge about a circle having the largest area (among shapes with the same perimeter). She intuitively used this knowledge to guide some of the groups to make their gardens more or less circular. But in her journal she wrote,

> After each group planted as many pots as we had seeds for, they made a little enclosure with chicken wire. B [one of the fathers helping out that day, and an expert gardener] helped many of the groups with that. His group also made a rectangle instead of a circular enclosure. He was right about that, because it is easier to water the plants in the middle and the circles are harder to water. M [one of the research assistants] is going to do a lesson on planning a garden as if it were in rows. This is the perfect reason to do this. As the plants get bigger and we're transplanting, the kids need to be able to reach their plants. So it's amount of chicken wire versus convenience of watering. [October 19]

Leslie's experience is particularly significant for me because I would have done the same thing. That is, I would have let my academic knowledge of mathematics guide my thinking in the design of the gardens. Yet, that may not have been the most efficient path to take from a gardening point of view. In González, Andrade, Civil, & Moll (2001), we discuss in more depth the issue of how our background in only academic mathematics may in fact limit our understanding of the mathematics in the household, which is often embedded in the practice itself (e.g., gardening).

The journal excerpt shows another example of how work in this project proceeded. Leslie turned this design issue into a learning opportunity by asking one of the research assistants, who was a graduate student in mathematics, to help her develop a lesson around the geometry in garden design. I think that one reason for the success of the garden module—and by success I mean our ability to capture the mathematical moments and turn them into learning opportunities-- was the amount of resources available (e.g., people with different kinds of knowledge). Not only did we have parents who contributed their expertise and resources, but also there were several other adults around with different ranges of expertise (including mathematics / mathematics education). Leslie welcomed the different contributions as she viewed them as a way to break the isolation that often characterizes a teacher's life. As she said in an interview,

> What I'm doing is using the Bridge personnel to help me figure out what it is I really need mathematically. So, like last week, M. [graduate student in mathematics] was talking about the volume of a cubic yard. I was getting there but I know I was hesitating and asking "is this right?" So she was able to step in and say "let's think about it this way." (…) It's really comforting having a support system right there saying "would you like me to step in?" And I could say yes or no. And I felt like I could co-teach with her and make the bridge for my kids when they weren't getting it, to a certain extent, and then she could take off on that. And that's really important to do that collaborative kind of teaching that honors what I'm learning and doing and what she already knows.

In an of end of the year reflective piece Leslie wrote,

> Marta helped me figure out scaling the information down [on the Amaryllis] so that it would fit into their notebooks, because it was becoming unwieldy. Marta also helped me take the risk of doing a perimeter/area experience with my students that helped me to assess just how much these kids knew in terms of how shape affected area. (…) Are there things that my students haven't gotten to mathematically? Yes, and that bothers me, too, but I have proven a point to myself. Much of the math that the kids did this year, was both authentic and valid for what we were doing. And that was the whole reason that I wanted to participate in this project. [April 10]

<u>A mathematical apprenticeship</u>

In my view, the garden module succeeded in engaging the students in doing challenging mathematics. This happened in part because "doing mathematics in school" took a different meaning. As Nunes (1999) writes:

> The nature of the social interactions in school in such that a problem is not solved for the student's sake, because of his personal interest in it, but for the teacher's sake, so that teachers can verify whether learning is taking or has taken place. (p. 48)

Students had a personal interest in the tasks and the outcomes. They became attached to their gardens; some students would get upset when they could not go out to work on them. As the teacher wrote in her journal, in relating the case of a student who became really upset when one of his plants died and blamed one of his peers for not covering it properly, "to me they are truly just plants, but to the kids they mean something else entirely."

I think that because of the overall inquiry approach that the teacher developed around the garden theme, the children took a personal interest on the mathematics problems that we posed in the classroom (e.g., graphing the growth of the amaryllis or finding the area of irregular shapes). The garden module reflects the key characteristics of out-of-school learning, which are (a) learning by apprenticeship; (b) working on contextualized problems; (c) control remains largely in the hands of the person working on the task (i.e., he/she has certain degree of control over tasks and strategies) (d) mathematics is often hidden; it is not the center of attention and may actually be abandoned in the solution process (Brown, Collins, & Duguid, 1989); Lave, 1988, 1992; Resnick, 1987). As Lave (1992) writes, "math learning in everyday practice is situated, dilemma-driven and the process for 'mucking about' with quantitative dilemmas are improvised in the process" (p. 80). Although the mathematics could have remained hidden, we had specific ideas as to what mathematics we wanted the students to explore and thus we made sure that we somehow forced those "improvisations" and "that these actions [were] systematically included in this shared mathematical learning activity" (van Oers, 1996, p. 105). In so doing, we developed examples of what a mathematical apprenticeship in a school setting may look like.

González (1995) writes,

> The basic premise of [FKT] is that classroom learning can be greatly enhanced when teachers learn more not just about their students' culture in an abstract sense but about *their particular* students and their students' households. … The teachers then draw upon that knowledge to develop curricula and teaching innovations that have roots in the experience and forms of knowledge of the students and of the community. (p. 3)

It is this idea of developing teaching innovations that not only build on the knowledge and experiences in the community but also in its *forms* of knowledge (e.g., apprenticeship) that is key to the equity agenda that drives my work in mathematics education. The construction and garden modules discussed in this paper are examples of apprenticeship-like approaches to classroom instruction. I argue that this apprenticeship approach is key to support the pedagogical shift that took place in both classroom practices. Through this shift we were able to engage students in what I described earlier in this paper as mathematically rich situations. For example, in the garden module students explored the problem of maximizing area of shapes with fixed perimeter. In the construction module, the mathematics was more elusive for the reasons I presented earlier (e.g., values, preserving the purity of the funds of knowledge), but what I did see was children's persistence and eagerness to engage in mathematical challenges (Civil, 2002a).

Conclusion: Building on Community Knowledge

The focus of this paper has been on issues related to the development of approaches to the teaching and learning of mathematics that build on students' and their families' backgrounds and knowledge. The work presented here took place in schools in low-income, ethnic and language "minority" communities. One of the key characteristics of our work is the approach we take to involve the community. To me, the fundamental contribution of FKT and Bridge is the involvement of teachers as researchers with the goal of learning about the community and about the resources and knowledge in their students' households. This is not about teachers applying generalities about different cultural groups. It is about teachers learning first-hand about the lived experiences of the community and about their developing rapport and trust ("confianza") with their students' families. As Leslie wrote in reflecting on the impact of household visits,

> Bridge has given teachers a chance to change the way they teach as they become more informed about the homes of their students. While we have much to do and little time to do everything, the household visit serves us well. It gives us a chance to connect with one family and through them a much larger community. It lets the family know who we are and by doing so we learn a lot about ourselves, (…) the way we respect other cultures and how we think about the classroom and its place in the community. Further, it provides a real look at the whole child. [January 23, 2000]

These teachers viewed parents (and other adults who are important in the life of their students) as resources towards the development of the modules. For example, in the construction module, the teacher talked about how her students would grow when parents come in and how they would use them as resources to answer their questions. And Leslie in an interview said,

> The whole idea of working with parents and bringing their ideas forth, inviting them as experts and maintaining them in the classroom in a different way than just grading papers and dittoing and listening to a child read is a very powerful connection. You know, I think that if parents could really feel as though they are part of the class and what they do in communities and in families fits in with the curriculum…

Parental involvement in low-income, ethnic and language “minority” communities tends to be in tasks such as monitoring the cafeteria, helping out with bulletin boards, fund-raising efforts. Parents may be present in the classroom but it is usually to assist with logistic and bureaucratic activities, not to contribute to the academic content (Civil & Andrade, 2003). Instead, the examples presented in this paper show parents contributing as resources for the academic component. This idea of involving parents (and other community members) as direct contributors to the curriculum is what we describe as parents as intellectual resources. We seek to learn from the community and to build our mathematics instruction on these adults’ knowledge and experiences as well as on their forms of knowledge.

Notes

1. 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. The contents, findings and opinions expressed here are those of the author and do not necessarily represent the positions or policies of OERI, NIEARS, or the USDoE.

2. A “cascarón” is a confetti filled eggshell attached to a colorful paper maché cone base.

References

Abreu, G. de (1995). Understanding how children experience the relationship between home and school mathematics. *Mind, Culture, and Activity: An International Journal*, *2*, 119-142.

Bishop, A. (1994). Cultural conflicts in mathematics education: Developing a research agenda. *For the Learning of Mathematics*, *14* (2), 15-18.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18* (1), 32-42.

Civil, M. (1992). Entering students' households: Bridging the gap between out-of-school and in-school mathematics. In A. Weinzweig & A. Cirulis (Eds.), *Proceedings of the 44th International Meeting of ICSIMT* (pp. 90-109), Chicago: ICSIMT.

Civil, M. (1993). Household visits and teachers' study groups: Integrating mathematics to a socio-cultural approach to instruction. In J. R. Becker & B. J. Pence (Eds.) *Proceedings of the Fifteenth Annual Conference of the North American Chapter of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 49-55). Pacific Grove, CA: San José State University.

Civil, M. (2002a) Culture and mathematics: A community approach. *Journal of Intercultural Studies*, *23*(2), 133-148.

Civil, M. (2002b). Everyday Mathematics, Mathematicians' Mathematics, and School Mathematics: Can We Bring Them Together? In M. Brenner and J. Moschkovich (Eds.), *Everyday and academic mathematics in the classroom. Journal of Research in Mathematics Education Monograph #11* (pp. 40-62). Reston, VA: NCTM.

Civil, M. & Andrade, R. (2002). Transitions between home and school mathematics: Rays of hope amidst the passing clouds. In G. de Abreu, A. J. Bishop, N.C. Presmeg (Eds.), *Transitions between contexts of mathematical practices* (pp. 149-169). Boston, MA: Kluwer.

Civil, M. & Andrade, R. (2003). Collaborative practice with parents: The role of the researcher as mediator. In A. Peter-Koop, V. Santos-Wagner, C. Breen, & A. Begg (Eds.), *Collaboration in teacher education: Examples from the context of mathematics education* (pp. 153-168). Boston, MA: Kluwer.

Civil, M., & Kahn, L. (2001). Mathematics instruction developed from a garden theme. *Teaching Children Mathematics, 7,* 400-405.

Civil, M. & Planas, N. (2004). Participation in the mathematics classroom: Does every student have a voice? *For the Learning of Mathematics*, *24* (1), 7-12.

Cooper, B. & Dunne, M. (2000). *Assessing children's mathematical knowledge: Social class, sex and problem-solving*. Philadelphia, PA: Open University Press.

González, N. (1995) (Ed.). Educational innovation: Learning from households. *Practicing Anthropology*, *17*(3), 3-24.

González, N. (1996). *Applied anthropology as educational innovation: Learning from households*. In Final Report: Funds of knowledge for teaching. Principal investigators, L. Moll, N. González, M. Civil.

González, N., Andrade, R., Civil, M., & Moll, L. C. (2001). Bridging Funds of Distributed Knowledge: Creating Zones of Practices in Mathematics. *Journal of Education for Students Placed at Risk* *6*(1&2), 115 - 132.

González, N., Moll, L., & Amanti, C. (Eds.) (in press). *Funds of knowledge: Theorizing practice in households, communities, and classrooms*. Mahwah, NJ: Lawrence Erlbaum.

Kahn, L.; & Civil, M. (2001). Unearthing the mathematics of a classroom garden. In E. McIntyre, A. Rosebery, & N. González (Eds.), *Classroom diversity: Connecting school to students' lives* (pp. 37-50). Portsmouth, NH: Heinemann.

Lave, J. (1988). *Cognition in practice: Mind, mathematics, and culture in everyday life*. New York: Cambridge University Press.

Lave, J. (1992). Word problems: A microcosm of theories of learning. In P. Light & G. Butterworth (Eds.), *Context and cognition: Ways of learning and knowing* (pp. 74-92). Hertfordshire, England: Harvester Wheatsheaf.

Lave, J. (1996). Teaching, as learning, in practice. *Mind, Culture, and Activity: An International Journal*, *3*(3), 149-164.

Millroy, W. (1992). An ethnographic study of the mathematical ideas of a group of carpenters. *Journal for Research in Mathematics Education*, Monograph number 5.

Moll, L.C. (1992). Bilingual classrooms and community analysis: Some recent trends. *Educational Researcher 21*(2), 20-24.

Moll, L., Amanti, C., Neff, D., & González, N. (1992). Funds of knowledge for Teaching: A qualitative approach to developing strategic connections between homes and classrooms. *Theory into Practice*, *31*(2),132-141.

Moll, L.C., & Greenberg, J. (1990). Creating zones of possibilities: Combining social contexts for instruction. In L.C. Moll (ed.), *Vygotsky and education*. Cambridge: Cambridge University Press.

Nunes, T. (1999). Mathematics learning as the socialization of the mind. *Mind, Culture, and Activity: An International Journal*, *6*(1), 33-52.

Nunes, T., Schliemann, A., & Carraher, D. (1993). *Street mathematics and school mathematics*. New York: Cambridge University Press.

Resnick, L. B. (1987). Learning in school and out. *Educational Researcher*, *16* (9), 13-20.

Rogoff, B. (1994). Developing understanding of the idea of communities of learners. *Mind, Culture, and Activity*: *An International Journal, 1*, 209-229.

Sandoval-Taylor, P. (in press). Home is where the heart is: Planning a funds of knowledge-based curriculum module. In N. González, L. Moll, & C. Amanti (Eds.), *Funds of knowledge: Theorizing practice in households, communities, and classrooms*. Mahwah, NJ: Lawrence Erlbaum.

Schliemann, A. D. (1995). Some concerns about bringing everyday mathematics to mathematics education. In L. Meira and D. Carraher (Eds.) *Proceedings of the 19th PME conference*,Vol. 1 (pp. 45-60). Recife, Brazil: Universidade Federal de Pernambuco.

van Oers, B. (1996). Learning mathematics as a meaningful activity. In L. Steffe and P. Nesher (Eds.), *Theories of mathematical learning*. Mahwah, NJ: Lawrence Erlbaum, 91-113.

Yackel, E. & Cobb, P. (1996). Sociomathematical norms, argumentation, and autonomy in mathematics. *Journal for Research in Mathematics Education, 27*, 458-477.