PARENTS AND TEACHERS DOING MATH TOGETHER

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Collaborative partnerships between families and teachers have the potential to support and transform students' mathematics learning experiences. This study focused on interactions among mothers and teachers of multilingual elementary grade students who participated together in workshops focused on teaching and learning mathematics. We analyzed participants' engagement in open-ended, culturally responsive mathematics tasks designed to foster collaboration and equitable participation. We describe several findings related to the potential of these tasks, including how they supported opportunities a) to recognize one another's strengths; b) to challenge traditional power differentials between parents and teachers, and c) to collaboratively generate mathematical ideas. We also discuss challenges that arose, and implications for the design of collaborative learning experiences for teachers and parents.

Key Words: equity, inclusion, diversity; problem solving; culturally relevant pedagogy; professional development

This study is part of a broader research project focused on an innovative mathematical partnership that engages teachers, parents, and multilingual children in elementary schools in underserved, predominantly minoritized communities. A central aim of this work is to develop parent-teacher partnerships that enhance mathematics learning for multilingual students.

Traditional school-based approaches to parental engagement can be particularly problematic for multilingual families from underserved communities, as they are often school-centric and adhere to deficit-based views about families' support of their children's learning (Olivos, 2006). Needed are innovative, transformative models for parent-teacher partnerships that build on the strengths and resources that participants bring, and that recognize families' deep commitment to education (González et al., 2005; Jiménez-Castellanos et al., 2016).

To address these challenges, our partnership model integrates two approaches to advancing equity in education- funds of knowledge (González et al., 2005) and positioning theory (Davies & Harré, 1990; Van Langenhove & Harré, 1994). While both theories have been applied in mathematics education, they have not been integrated in a parent-teacher partnership program with the aim of enhancing mathematics learning for multilingual students.

Funds of knowledge refers to the historical accumulation of skills, knowledge, culture, and ways of interacting in communities and households (Vélez-Ibáñez & Greenberg, 1992). Applied to school-family partnerships, a funds of knowledge perspective explicitly contests deficit views of culturally and linguistically diverse communities through a focus on families' knowledge and experiences as intellectual resources that support learning (Civil & Andrade, 2003; González et al., 2005). Research guided by a funds of knowledge approach emphasizes the importance of two-way dialogues between families and teachers, and opportunities to build relationships and

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trust (Delgado-Gaitán, 2012; Jiménez-Castellanos et al., 2016). This work also emphasizes the complexity of the transformation of household knowledge into mathematical knowledge for school practice (González et al., 2001). Other challenges include the power issues that may arise when parents and teachers work together on mathematics (Civil & Bernier, 2006), and that parents' mathematical resources are often unnoticed by teachers, often due to language differences or the informal nature of the ideas (Quintos, et al., 2019). Our work builds on the promising directions highlighted in prior research guided by funds of knowledge approaches, while also considering documented challenges (Civil & Quintos, 2009; Quintos, et al., 2019).

To deepen our understanding of these challenges, we draw on positioning theory as it focuses on how social interactions influence opportunities to participate, which in turn impact identity development and learning. Positioning theory (Davies & Harré, 1990; Van Langenhove & Harré, 1994), explores the narratives that people use to position themselves and others in social interactions. Positioning theory attends to how participants use multiple forms of discourse (oral language, gestures, written text), in moment-to-moment interactions, to position themselves and others in ways that over time, lead to storylines about each participant's rights or duties to act in particular ways. In mathematics education, positioning theory has been used to understand how teachers position students in ways that affirm their mathematical competence, or how students position themselves, or one another, in ways that support or undermine their opportunities to contribute ideas (Chval et al., 2015; Esmonde & Langer-Osuna, 2013; Turner et al., 2013). While positioning theory has been applied to analyze interactions within mathematics classrooms, in our partnership model we use positioning theory to understand interactions among mothers and teachers in project workshop sessions, with particular attention to distribution of power and opportunities to learn from one another.

Methods

Context and Participants

This research is part of a larger NSF-funded, collaborative research project that involves three universities, and their partner school districts in diverse geographic regions of the country. This analysis focuses on workshops with mothers and teachers at one site, a large public school district in the southwest. Participants included 9 2nd through 5th grade teachers, from 4 partner schools, who range in teaching experience from 3 to 25 years. The partner schools serve a predominantly Mexican American, Mexican immigrant student population, many of whom have Spanish as home language. While three of the schools use English as the language of instruction for all subjects, one of the partner schools has a dual language model and mathematics is taught in Spanish. Four teachers spoke both Spanish and English, three spoke only English, and two spoke English and other non-Spanish languages. Participants also included 11 mothers (1 was a grandmother) of 2nd through 5th grade multilingual students. All mothers spoke Spanish as a home language, with varying levels of English/Spanish proficiency. Five of the mothers had attended school in Mexico and had been living in the United States for over 9 years. Mothers were invited to participate by the participating teachers.

Workshop Activities

This study focuses on three workshop sessions in Fall 2022. Each session included opportunities for mothers and teachers to work together on an open-ended mathematics task. Other activities included time to reflect together on mathematics learning experiences, to discuss classroom videos, and to build relationships by sharing personal stories and learning about one another's background. In this analysis, we focused specifically on mothers' and teachers' interactions during the joint mathematics tasks. We designed these tasks with several principles

in mind. First, the tasks were open-ended, with multiple possible answers depending on decisions made by participants. Second, the tasks reflected mathematics content relevant to our target grade levels (e.g., fractions, multiplication, and division), and connected to familiar practices or contexts in the local community. We specifically aimed to connect to contexts that might be familiar to mothers, to position their knowledge and experiences as resources.

During each workshop, a facilitator (a member of the research team) presented the mathematics task, in both Spanish and English, often using images or video clips to build a shared understanding of the context. The facilitator then invited participants to share experiences relevant to the task with the group, and to brainstorm possible strategies or problem-solving approaches. Next, parents and teachers worked on the task in collaborative groups (typically one or two teachers with two or three mothers). The facilitators circulated among groups, supporting participants with questions, and encouraging collaboration. Following small group work, groups shared solution strategies and compared the different approaches.

Collaborative Mathematics Tasks

In the first workshop, the mathematics task focused on making paper flowers, like those used in Day of Dead (*Día de los Muertos*) celebrations. The problem posed was: How many flowers can you make from a package of 24 sheets of tissue paper? To solve the task, participants made decisions about the size of the flowers and the number of layers of paper for each flower. In the second workshop, the mathematics task focused on a photograph of a sugar skulls display. The display included skulls of different sizes, arranged in multiple layers, and in rows and columns. (Sugar skulls are a common addition to Day of the Dead altars). The problem posed was: How much sugar would you need to make the sugar skulls in the display? Participants estimated the number of skulls of different sizes, and then used a sugar skull recipe to figure out how much sugar was needed. The mathematics task in the third workshop focused on the rows of bright-colored ribbons that adorn ballet folklórico skirts, which are used for traditional dances in various regions of Mexico. The problem posed was: How much ribbon do you need for one skirt? Participants used sample skirts as well as information about the length of the edge of the skirt compared to the length around the waistline or middle to estimate the ribbon needed.

Data Sources and Analysis

Data sources included video recordings of parents and teachers as they worked on the three mathematics tasks and shared their solutions. Recordings were summarized and transcribed for analysis. Transcripts were imported into Atlas-TI, a qualitative research program, for coding and analysis. Our analysis was guided by the following research questions: As parents and teachers engaged in collaborative mathematics tasks, to what extent did they have opportunities to:

- learn about one another's experiences, and to recognize the strengths and intellectual resources that each participant brings?
- challenge and reconstruct traditional power differentials between parents and teachers?
- collaboratively generate ideas and build knowledge?

Codes attended to the ideas and experiences shared by participants (e.g., personal stories, knowledge related to task context, mathematical ideas), and how participants positioned themselves and one another as they contributed ideas, including how power was distributed equitably or inequitably through these positionings. Differences in codes and interpretation were

resolved through discussion between researchers, and emerging themes were triangulated across data sources (across small groups, and across workshop sessions). In the next section, we describe our findings, organized by salient themes related to each research question. While the themes reported were evident across the three workshop sessions, for the purpose of this report, we focus on examples from the first mathematics task, making paper flowers.

Findings

Facilitator prompts and task contexts supported telling stories and sharing strengths

Across each of the three math problem solving sessions, we identified instances when both teachers and parents shared personal stories relevant to the task context to push forward the work of their group. These instances seemed to be supported by moves facilitators made as they launched each task. For example, in the paper flowers task, the facilitator asked participants, in Spanish and English, to raise their hand if they had made paper flowers in the past. When few participants responded, another facilitator offered further encouragement, ("*No sean tímidas, yo sé que varias de Uds. sí. Venga, venga*." (Don't be shy. I know some of you do. Come on, come on. (Said with humor in a jovial manner)). This prompted several mothers and teachers to raise their hands and share related experiences. Brooke, a mother noted that she knew how to make flowers with a different kind of paper. Rocio, a teacher shared that when she was young her mother taught her to make flowers with kleenex. *S*everal other participants indicated similar experiences. In response, the facilitator positioned the mothers and teachers as experts who had valuable experiences relevant to the mathematical task ("We have Brooke (mother) as an expert and Leonor (grandmother), and Rocio (teacher) [proceeds to name other mothers and teachers].. *y aunque la experiencia sea diferente, ellas tienen esas experiencias*" (and even though the experiences may be different, they still have these experiences).

This positioning by the facilitators seemed to prompt participants to continue to draw on their prior experiences as they worked on the task in small groups. For example, in one small group that included three teachers, a mother and a grandmother, the group was trying to decide how to cut the large sheet of tissue paper to make smaller rectangles that could serve as layers. They had multiple ideas about the size of the paper and how many layers they should use. Darla (one of the teachers) paused the conversation and explicitly asked Leonor (the grandmother who had previously indicated her experience making flowers), to share how she made flowers at home.

Leonor initially described an informal process based on visually cutting paper into different sizes, but when one of the teachers (Kevin) suggested partitioning the paper into 8 smaller parts, Leonor intervened and shared more mathematical details about her method. While most of the participants in this group were bilingual (Spanish/English) and moved between languages as they worked on the task this portion of the group conversation occurred mostly in English.

> Darla (teacher): (to Leonor) I know you make them at home, how big do you make them?
> Leonor (grandmother): different sizes, I just get the paper and I make them different sizes. … Darla (teacher): You just cut them, you don't think about the math? (smiles)
> Leonor (nods her head, and laughs): it's like *un puñito de esto (*it's like a pinch of this), a little bit of this, no measurements …
> Kevin (teacher): We could probably just do it like this [points to a drawing on Darla's paper, where she has used lines to partition the sheet of paper into 8 smaller sections]
> Leonor (grandmother): But how many inches is that one? That's too small.
> Darla: This paper (the whole sheet), they said we could cut it into fourths or sixths or eighths.

Leonor: I think sixths, look, it's already folded in 6 parts (opens a sheet of tissue paper that was previously folded to show that the paper was folded in 6 parts), and it [the size] is perfect. … What I do is if I get big pieces I get more paper [layers] to make a big flower. If you don't put like 5 [layers] it's not going to look good.

The group then discussed different numbers of layers and ultimately decided (likely based on Leonor's suggestion) to make small-medium size flowers that have 6 layers each. We found similar patterns across groups and across tasks, where participants - sometimes teachers, but often mothers, shared experiences relevant to the context that helped the group make decisions to move the problem solving forward. In some instances, these experiences were explicitly invited by another member of the group, as when Darla asked Leonor to share. But in other instances, participants spontaneously shared stories as they began to explore the task. For instance, Rocio (teacher) shared that her mother, who taught her to make flowers, always said that the more layers, the fuller the flower ("*entre más hojas, se va a ver más lleno"*). In both cases, this sharing of stories not only supported the groups' problem solving, but also helped participants learn about one another's knowledge and experiences -which over time, we conjecture, may support teachers to recognize parents' intellectual resources that support their children's learning.

Open-ended tasks created the potential to restructure power dynamics, though this potential was not always maintained

Our goal in designing open-ended, culturally relevant mathematics tasks was to foster equitable problem-solving spaces where both mothers and teachers contributed ideas, made decisions, and shaped solutions. Since none of the tasks included all the necessary information, but rather required decisions, assumptions, and consideration of multiple options, groups often began with a reciprocal dialogue where mothers and teachers worked together to make sense of the task. For example, the small group highlighted above began by re-reading the task, and then posing initial thoughts or questions. Leticia (mother) suggested that they could use rulers to measure the tissue paper sheets. Kevin (teacher) noted that they would need to determine how to cut the sheets, and Valeria (teacher) and Leonor (grandmother) suggested possible sizes (e.g., 6-inch by 4-inch rectangles). This initial sharing was followed by the invitation for Leonor to share how she made flowers at home. However, this reciprocal dialogue was short-lived, as two of the teachers (Kevin and Darla) began to guide the group's process, positioning themselves in a "teacher-like" role, and positioning the mother and grandmother to "follow along" with the mathematics. Kevin began this shift by naming "the math we need to figure out" and Darla continued, inviting the group to "do some math" as she stated and recorded the first problem they needed to figure out (If we cut 24 sheets into 6 pieces each, how many total pieces do we have?).

Kevin: So do we want to have an equal number of sheets in each flower, so there is nothing left over? (Other participants nod to affirm) Ok, so that is the math we need to figure out.

Darla: (taking a marker, to write on the group solution paper). So, we are deciding that we are going to cut it in 6? (writes "cut in 6" on group paper)

Kevin: 6, uh-huh.

Darla: But we have to keep in mind we're trying to figure out how many flowers would you make out of 24 sheets? …

Leonor: 24 sheets. So we have to get like a pair of numbers, *verdad*? (right?) (Looking at Darla, waiting for Darla to answer her question).

Darla: We might have to get even numbers to do the math, that's a good idea. Do you want to do some math?

Leonor: Yes.

Darla: So we have 24 sheets, right? And we're going to cut each sheet into 6 pieces. (Writes, "Decisions: Each sheet will be cut into sixths")

Darla and Kevin proceed to do the computation without input from the other participants. While Leonor previously positioned herself as an expert as she shared her flower-making knowledge, in this excerpt she accepted the role of student, asking Darla to verify her ideas (*verdad?),* and accepting Darla's invitation to follow along as she "does some math." This shift in power dynamics seemed prompted by the teachers' desire for the group to work together towards a single solution. While the open-ended task created the potential for participants to explore different decisions which could have led to different solutions, the teachers responded by narrowing the task and restructuring traditional teacher/parent power differentials.

In other instances, groups maintained the initial, reciprocal dialogue throughout their problem-solving work. In contrast to the prior example, participants strove to keep the task open to allow for diverse decisions among group members. When suggestions to agree on a common decision or solution arose, they were rejected in favor of allowing group members to explore different possibilities. This maintained a more open space for mothers and teachers to contribute and evaluate ideas. For example, Rocio and Nishaan (teachers) and Bárbara and Veronica (mothers) began by acknowledging that many solutions were possible. Next, they brainstormed several possibilities (large flowers with many layers, or tiny flowers with smaller rectangles).

When one of the teachers (Nishaan) suggested that they make a group decision about the number of layers, other participants pushed back, insisting that "We don't have to do the same size."

Rocio (teacher): *No hay una sola forma* (There is not just one way)

Verónica (mother): *Si las vamos a hacer de 5 (capas) cada una, o si vamos a usar las 24 hojas para hacer una sola flor grande?* (Are we going to make them 5 layers each, or are we going to use the 24 sheets to make one large flower?) *... Eso es lo que ellos quieren, que no hay sólo una respuesta.* (That is what they want, that there is not just one answer)

Rocio: *Que no hay una sola no más*. (That there is not just one) …

Bárbara (mother): (agrees) We can make [them] different because it is not 1 correct answer. We can make 1, we can make [it with] 24 layers, or we can make tiny little flowers and make 100 f*lowercitas* (little flowers).

Nishaan (teacher): So you guys want to decide how many layers we are going to do? Or not? Rocio: Well, she (Bárbara) wants to make her own…

Bárbara: We don't have to do the same size

Rocio: No, we don't have to do the same size. You can do your size; however you want and just explain however many layers you want.

Bárbara: I don't like that question, because like… ? (Gestures, holding up both hands and raising shoulders to indicate that the math task is lacking direction)

Verónica: There is so much left out. There are so many right answers. So, what we are trying to say is we either put all our papers together and make one flower, or we just cut them in different sizes and make a bunch of different flowers?

Bárbara*: Me intriga más resolver el problema matemático que hacer la flor* (I am more interested in solving the math problem than making the flower)

While both mothers expressed puzzlement, or even frustration towards the task (i.e., "I don't like that question" and "There is so much left out"), they opted to keep the task open. Following

this exchange, participants explored multiple solutions, sometimes working independently, and other times coming together to share their discoveries. They made tables to organize possible solutions (Nishaan, teacher, and Veronica, mother), and folded the paper to compare different flower sizes (Rocio, teacher, and Bárbara, mother). Their efforts to maintain the openness of the task created space to pursue diverse ideas, which seemed to support a more equitable distribution of power.

This led to collaborative generation of knowledge, which we explore next.

Maintaining space for diverse ideas supported co-construction of knowledge

Each math problem solving session ended with a whole group discussion where participants shared their thinking. While small groups often came together to share a group solution, we found that it was not a push for consensus that facilitated the co-construction of knowledge, but rather interactions that created space to explore multiple ideas. For example, in the group highlighted above, Bárbara (mother) and Rocio (teacher) folded sheets of tissue paper to explore different sized paper flowers. They worked in parallel, each experimenting with different folds and occasionally exchanging ideas. At one point, Bárbara noticed that while they both folded the paper in eighths, the results were flowers that appeared to be different sizes. This generated a rich dialogue between Bárbara, Veronica, and Rocio about how the direction of the folds into eighths impacts the shape of the resulting rectangles, but not the area.

> Bárbara (mother): *Ella (Rocio, teacher) la dividió en 8 (rectángulo) y yo lo dividí en 8 (cuadrado), Nuestros ochos fueron diferentes. (*She divided it in 8 (rectangle shape) and I divided it in 8 (square shape). Our eights were different.)
>
> Verónica (mother*): Me está saliendo un nudo en el cerebro.* (I am getting a headache) … Rocio (teacher): *¿Y qué hay de la otra medida? Tienes que tener dos medidas.* (starts to
>
> gesture the length and the width) (And what about the other measurement? You must have two measurements.)
>
> Bárbara: *El mío no le he medido, pero yo le calculo 6x5 y el de ella también lo dividió en 8. (*I did not measure mine, but it looks like 6 by 5, and she also divided it in 8).
>
> Facilitator1: *Se supone que todos los papeles son del mismo tamaño, si lo dividieron en 8 las dos se supone…* (All the sheets are supposedly the same size, so if you both divided it in 8, then it should be. …)
>
> Bárbara: *Porque nuestros doblados son distintos. Yo lo doblé así, y ella lo dobló así* (Because our folds were different. I folded it like this, and she folded it like this)
>
> Verónica: *A lo largo.* (The long way) Like the area. The area is the same, just different shape. Rocio: (nods to agree)
>
> Verónica: So you know, if you have 5 rows of blocks, you know, the way some of the kids are learning, you have 5 blocks going this way and you have 5 blocks going this way, you have your area, right? 25, so it's perfectly square. (Gestures to show rows and columns). But then and you make a rectangular, you are still using the same amount of squares, so it means you still have the same area, just a different shape.

We found similar patterns across groups and tasks – when mothers and teachers kept tasks open and explored diverse ideas, their interactions were often characterized by a collaborative generation of knowledge, as in the previous exchange. This co-construction of mathematical ideas was also evident later in the group's discussion, as Bárbara, Verónica, and Nishaan became increasingly interested in systematically representing a range of possible solutions. Verónica

continued to record possible solutions, repeatedly dividing the tissue paper in half to make smaller and smaller flowers, noting, "You go from one big flower, which is the least you can do, and the more you keep going, the more you have." She also described the difference between what is possible mathematically "you could even do 128" (cutting the paper into 128 parts), and what is realistic "obviously it is going to be super small, but in the math I mean, it could be done." Nishaan pursued a similar strategy, starting with a single 6-layer flower, and then cutting the tissue paper in half to make 2 smaller 6-layer flowers, and then in half again, to make 4 smaller flowers 6-layer flowers. After listening to Nishaan describe her process, Verónica noted her agreement, and the similarities in their approaches. Meanwhile, Bárbara attempted to write a general formula for the total number of flowers, given variation in how the tissue paper was divided (number of parts), and the number of layers per flower. She defined different variables and explored various ways to combine them in an equation. She insisted that a general equation to represent all the solutions of the group had to be possible, "*No sé si me ecuación es correcta pero he estado buscando porque tiene que haber, tiene que ….* I don't know if my equation is correct, but I have been searching because there has to be an equation, there has to be).

We find this interaction particularly important because as the mothers and teachers continued to explore multiple ideas – without a focus on consensus – this led to the co-construction of rich mathematical ideas, such as ideas about the maximum and minimum number of solutions, the difference between mathematical and real-world solutions, and generalized equations. We conjecture that these collaborative exchanges can foster partnerships between parents and teachers that could enhance ongoing work to support children's mathematics learning.

Discussion

Parents and teachers are often called to be partners in children's education, yet the school system often positions them in asymmetrical relations, particularly in marginalized communities. Furthermore, efforts to disrupt these historical power asymmetries are often superficially successful (Quintos et al., 2019). The analysis of the interactions of mothers and teachers as they participate in mathematical tasks shows the possibilities and challenges of creating spaces to support their collaboration. Their participation in open-ended, culturally relevant tasks allowed parents and teachers to learn about one another's experiences and strengths. Also, the individual disposition of teachers or parents to share and listen to each other is another key factor, which can be reinforced by the facilitation of the tasks.

We described several contrasting interactions as mothers and teachers solved mathematical tasks. In one group, teachers adopted a "teacher-like" role, positioning parents as students or listeners. The teachers defined the question and led the problem solving. The discourse was mostly controlled by the teachers and consequently, the task was interpreted more narrowly. In the second group, mothers and teachers maintained the openness of the task, which allowed them to explore and construct diverse mathematical ideas. This openness of the task seemed key to disrupting hierarchical power relations, and counters narrow views of school mathematics that exclude different processes for sense making. Mothers were positioned as knowledgeable contributors of ideas, countering deficit views of families in underserved communities.

While the interactions noted above were supported by multiple features of the workshops, including the privileging of both Spanish and English, time to build relationships, and to discuss mathematics learning experiences, we conjecture that the open-ended tasks and connections to relevant contexts offered support. Participants had opportunities to see beyond their teacher or parent role, and to engage with one another in a more informal, personal manner. These types of interactions have the potential to nurture connections between parents and teachers (Civil &

Bernier, 2006; Civil & Quintos, 2009), and support teachers to perceive families as holders of mathematical knowledge (Civil & Andrade, 2003; González et al., 2001).

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