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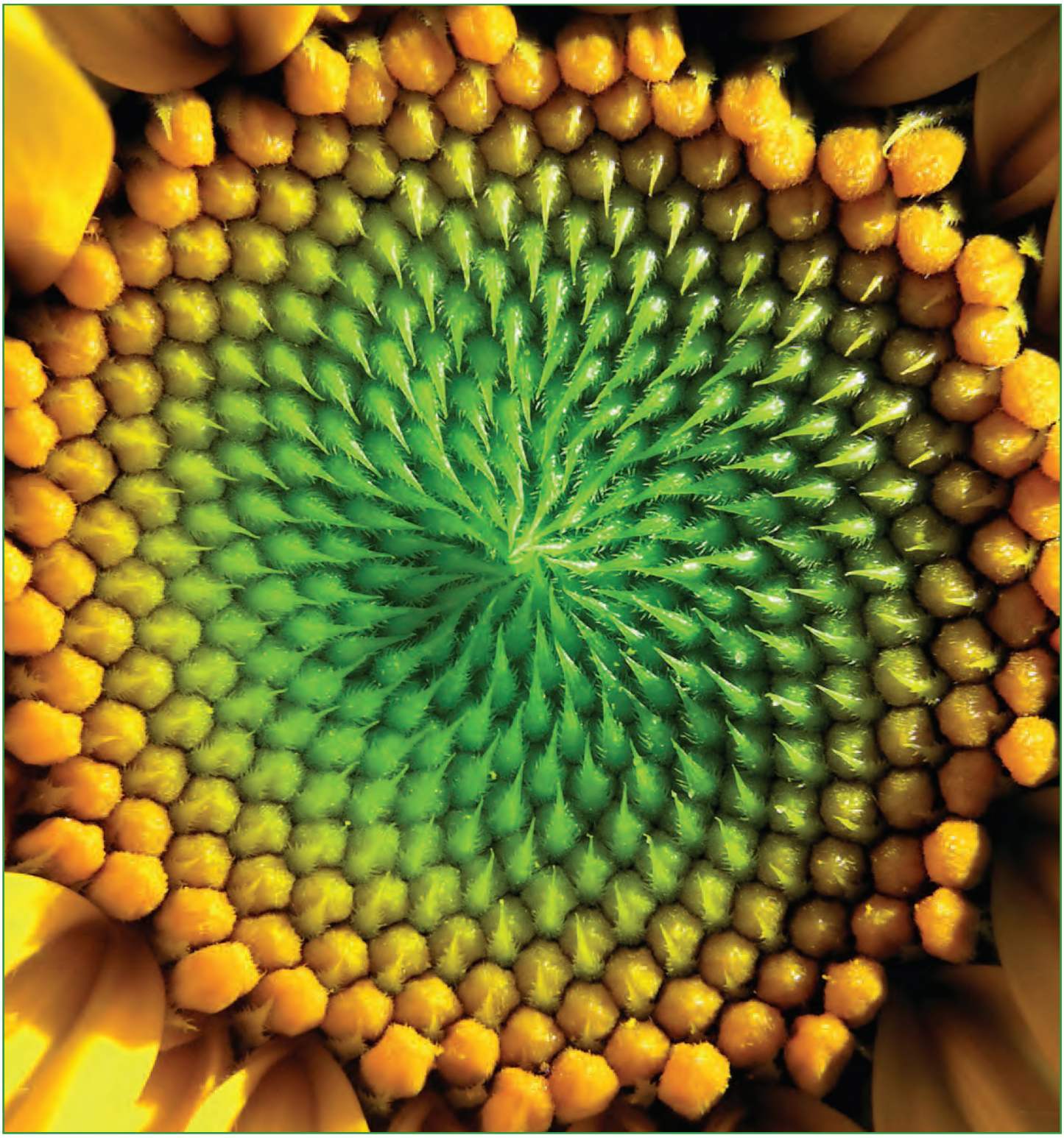

National Council of Supervisors of Mathematics *www.mathedleadership.org*

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Preparing Teachers To Cultivate Parent-Child Collaboration In Mathematics

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Introduction

The National Science Foundation, through its funding of curriculum projects such as *Everyday Mathematics* that include a family component, demonstrates its recognition of the significance of families in mathematics education. This is just one example of several curriculum projects and school initiatives that value collaboration with families. Such efforts respond to the National Council of Teachers of Mathematics' call to build family understanding of current school mathematics goals and instructional practices so that home and school may support each other (National Council of Teachers of Mathematics, 2000).

However, in-service professional development efforts for teachers and administrators focus primarily on understanding the curriculum's teaching and learning objectives (Ball, 1996; Nelson & Sassi, 2000). Less emphasis is placed on efforts to understand how families view these objectives and to develop ways to involve families meaningfully in their child's learning of mathematics (Remillard & Jackson, 2006).

This is true for pre-service teacher education as well. The formal preparation of educators to partner with families in any form is under-emphasized in teacher education programs (Shartrand et al., 1994; Hiatt-Michael, 2001; Witmer, 2005). This is despite research findings suggesting that productive collaboration with families has a positive impact on attitudes towards mathematics and mathematics achievement (Bezuk, Whitehurst-Pane, & Aydelotte, 2000l; Kliman, 1999).

Examinations of the nature of teacher collaboration with families have documented that many teachers do not have adequate knowledge and skills necessary for promoting family partnerships that support students' academic achievement (Ratcliff & Hunt, 2009). For example, some researchers found teacher collaboration with families consisted primarily of a "laundry list that good parents do" (Calabrese Barton et al., 2004; p.3). Other researchers found that teacher collaboration with families focused only on "how to" strategies for dealing with situations such as "difficult parents" or parents of children with learning disabilities Ferrara and Ferrara (2005).

To strengthen how teachers might productively collaborate with families, we designed a university-sponsored mathematics professional development program that would provide opportunities for teachers to investigate "parent-child collaboration" while working with family members in their own mathematics classrooms, with an eye to how what they learned from these investigations might inform their efforts to build strong collaborations with families around mathematics teaching and learning. The term "parent-child collaboration" in mathematics refers to the manner in which a parent and child work together on mathematical tasks such as daily homework and projects.

Assessment of this professional development program was conducted to determine its impact on teacher understanding of how and why parents and children work together the way they do in mathematics and the role of the teacher in nurturing productive parent-child collaboration.

Literature Review

The most basic premise of Vygotsky's theory (1978) is that a child's intellectual development is a produce of their social environment. Vygotsky points out that this social environment contributes to the cultivation of a child's higher order thinking skills when adults provide guidance within a child's zone of proximal development—a cognitive state in which the child cannot yet quite solve a problem by themselves and is responsive to social guidance. This social guidance is often referred to as "scaffolding."

A link between Vygotsky's view and family involvement in mathematics education exists. Researchers find that families, as a unit of the social environment, act as positive influences for attaining success in mathematics when they provide assistance that reflects a scaffolding approach (Connor & Cross, 2003; Vygotsky, 1978; Wood & Middleton, 1975). Family members using such an approach are attuned to the needs of the learner, guiding the learner within his or her zone of proximal development, and readjusting their assistance as the learner progresses to a new ability level. Guidance of this nature reflects what Hyde et al. (2006) term as "quality" assistance that is just as important, if not more, as the quantity of assistance.

However, many family members face the challenge of their lack of familiarity with the reform mathematics curriculum materials (Burns, 1998). These family members may struggle when trying to assist their child in a manner reflective of the scaffolding approach. They may also feel uncomfortable abandoning a drill and practice approach that worked well for them when they were in school (Epstein & Jansorn, 2004). Researchers warn that unfamiliarity and resistance can challenge reform efforts when family members choose to assist their child in ways that only mirror their past learning environment as opposed to that of their child's (Remillard & Jackson, 2006).

Given the difference family members can make in a child's mathematics performance, it is important for teachers to support and encourage collaborations in ways that address the challenges family members may feel when they seek to support their child's mathematics learning. This is particularly true for family members that come from different learning environments, have low levels of formal education, or are from low-income communities. Civil and Bernier (2006) highlight the need to move teachers away from a "deficit model" where family members are underutilized and devalued, to a mindset where family members are valued as "intellectual resources" regardless of their economic, cultural, and educational backgrounds.

Calabrese Barton et al. (2004) reflect this focus on engaging family members, regardless of their backgrounds, using their Ecologies of Engagement Framework where they define parental engagement as "a dynamic, interactive process in which parents draw on multiple experiences and resources to define their interactions with schools and among school actors" (p. 3). This framework represents a shift from focusing primarily on what family members do to engage in their children's education, to also learning about the "hows and whys" behind their actions. This shift enhances Epstein's (1987) theory of overlapping spheres of influence that identifies students as the main actors in their education, supported by others at home, at schools, and in their communities. When attention is given to Epstein's concept of multiple forms of support, with a lens reflective of the deep understanding advocated by Calabrese Barton et al. (2004), it is likely that productive collaborations that benefit students, strengthen families, and improve schools can be designed.

To determine how best to structure a learning environment for teachers that addressed these productive collaborations while also providing parents with insight into their child's learning of mathematics, an investigation of best practices for teacher education and family involvement initiatives was conducted. During that investigation, it was noted that Situated Cognitive Theory (Choi & Hannifin, 1995; Jonassen & Rohere-Murphy, 1999) suggests to teacher educators that new knowledge comes from implementing and observing actual school-based teaching. Darling-Hammond & McLaughlin (1995), Lee (2005), and Sawchuck (2009), as a result of their evaluations of teacher education and professional development programs, found that continued support from teacher educators, coupled with opportunities for teachers to share feedback with their colleagues, cultivates professional growth in a community of practice.

When reviewing the research on how best to support family engagement, findings favored efforts that focus on building parents' understanding of the changes in mathematics teaching (Sheldon & Epstein, 2001), especially the use of manipulatives as tools for learning (Mistretta, 2004; Orman, 1993; Dauber & Epstein, 1993; Epstein, 1986). In addition, parents were found much more knowledgeable

about their children's learning of mathematics at the close of a series of activities where both parents and children engaged in mathematics tasks together (Tregaskis, 1991; Lachance, 2007; Fagan, 2008). These established learning conditions for parents as well as those described previously for teachers provided the foundation for the professional development program that was crafted and is discussed in this paper.

Methods and Procedures

PARTICIPANTS

An inner-city nonpublic school population of 147 pre-kindergarten through 8th grade students and their parents, along with their seven mathematics teachers agreed to participate in the professional development program. There was one teacher for both pre-kindergarten and kindergarten, one teacher for each of grades 1 through 5, and one teacher for grades 6 through 8. The 2nd grade teacher had 18 years of teaching experience, while the 1st grade teacher had three years, the pre-kindergarten/kindergarten teacher two years, and the others were first year teachers. Five teachers were state certified and two were working towards it. Four teachers were Caucasian, two were Hispanic, and one was Pacific Islander. In addition to receiving professional development credit, the teachers also received a stipend for their participation in the program.

The students' ethnic backgrounds consisted of 82% Hispanic, 14% Afro-American, 3% Caucasian, and 1% Asian. There were 75 male and 72 female students, and there was one class per grade level except for pre-kindergarten and kindergarten, which were merged due to the small number of students in each.

All families in the school participated in the professional development program and received incentives for their involvement; these incentives included home instructional materials, student dress-out-of-uniform passes, and free raffle tickets for prizes consisting of school supply store and supermarket gift cards. Dinner was also served prior to each of the family sessions. All families were fluent in English and were classified as low socioeconomic status, with approximately 81-90% of the children qualifying for free lunch.

PROFESSIONAL DEVELOPMENT PROGRAM

The professional development program consisted of four 2-hour teacher workshops and three 2-hour family sessions that took place over eight weeks during the first half of the school year. In these sessions, participating teachers engaged their own students and parents in mathematics tasks, gathered and analyzed data, and shared findings with their colleagues.

During the four 2-hour teacher workshops, teachers prepared to facilitate the family sessions, using the same mathematics tasks they would later use with family members during the family sessions. Teachers also learned how to collect data (surveys, field notes, work samples, and written reflections) during the family sessions and analyze these data. Finally, teachers discussed their findings at workshop sessions scheduled a week after each family session in order to create opportunities to share and discuss data on an ongoing basis with the other teachers participating in the project. Because the grades 6 through 8 group of family members was large, several additional teachers joined these teacher workshop sessions in order to be able to provide support to the grade 6 through 8 mathematics teachers facilitating the family sessions for those grade levels.

The three 2-hour family sessions were facilitated by these participating teachers in the evening with support from the project staff and the school principal. The sessions were designed to inform and engage family members, promote reflection, and build collaboration between parents and children with regard to mathematical learning. Because tangrams were being used by teachers during their mathematics instruction as a result of prior professional development at the school, and were familiar to both teachers and students, these materials were also a focus of the family sessions.* All teacher workshop and family session guidelines as well as related hand-out materials used throughout the professional development program can be found in Teachers Engaging Parents and Children in Mathematical Learning: An Approach for Nurturing Productive Collaboration (Mistretta, 2008a).

The family sessions were announced with an invitation to parents that included a request for information about times that would best suit their schedules. To personalize

* Tangrams consist of seven geometric shapes including two large triangles, one medium triangle, two small triangles, one square, and one parallelogram.

the invitation, students designed their own covers, and teachers then stapled the invitation inside each student's cover and sent them home. The sessions were then scheduled, taking parent time constraints into account, to the extent possible.

At the beginning of the first family session, teachers asked parents to complete a survey designed to help them better understand how and why parents and children work together at home. After administering the survey, the teachers outlined the agenda for each of the family sessions. Teachers then led a discussion on constructivist teaching practices that addressed how these instructional practices use a developmental approach, with individual learners actively building new knowledge as they interact with people and things in their environment (Cathcart et.al, 2006). The discussion then turned to the topic of using manipulatives, specifically tangrams, as a tool to support mathematical learning. Teachers presented the tangram set and talked with parents about how they would be participating in tangram activities with their children in ways that were similar to how their children were exploring tangrams in their classrooms. A question and answer session followed so that parents could ask questions and comment on the content of the session.

The second family session provided a concrete, active learning environment for participating families. Teachers distributed tangram sets and let parents and children know they were about to engage in activities involving spatial reasoning, computational skills, and problem solving. Time was provided for free exploration to foster parents' familiarity with the pieces. After eliciting information about the size and shape of the pieces, teachers posed the following questions concerning the relationships among the pieces:

- How does the small triangle compare with the medium triangle?
- How does the small triangle compare with the large triangle?
- How does the medium triangle compare with the large triangle?
- What tangram pieces can be joined together to form other tangram pieces?
- How many ways can you cover the large triangle with other tangram pieces?

Additional small triangles were distributed in case families wished to use them when exploring the relationship between the small and large triangle. Teachers circulated among their families to give assistance and observe interactions between the children and their parents.

Families then discussed as a whole group what they had discovered about their tangram sets. For example, the small triangle is half the size of the medium triangle, the small triangle is one-fourth the size of the large triangle, and the medium triangle is half the size of the large triangle. Other discoveries were that the two small triangles can form both a square and a parallelogram shedding light on the fact that both shapes have the same area because they both contain the same amount of space (the two same sized small triangles) but just in different representations. By covering the large triangle in different ways, families discovered how the large triangle can consist of: two medium triangles, two small triangles and the medium triangle, two small triangles and the square, or two small triangles and the parallelogram.

To initiate an activity that involved spatial reasoning and connected their discoveries with a computational task (Fuys & Tishler, 1979; ETA/Cuisenaire, 2007), teachers asked their families to arrange the seven tangram pieces into an outlined cat that was distributed to them. A monetary value was assigned to the smallest triangle of the tangram set and teachers posed the following questions according to grade level:

- Grades Pre-K to 2: How much does the cat cost if the smallest triangle costs 1¢?
- Grades 3 to 5: How much does the cat cost if the smallest triangle costs 20¢?
- Grades 6 to 8: How much does the cat cost if the smallest triangle costs $3.25?

Parents and children were instructed to use what they discovered about the relationships among the tangram pieces to arrive at their solutions. For the Pre-K to Grade 2 families, an outlined cat with the tangram shapes drawn inside was used, and an additional 14 triangles were distributed so the cat could be covered with 16 triangles, thus providing these children with the option of finding the cost of the cat by counting by ones rather than adding larger numbers or multiplying. Teachers advised parents not to do all of the telling, but rather, explore their children's mathematical thinking by asking prompting

FIGURE 1: *Grade 1 Work Sample*

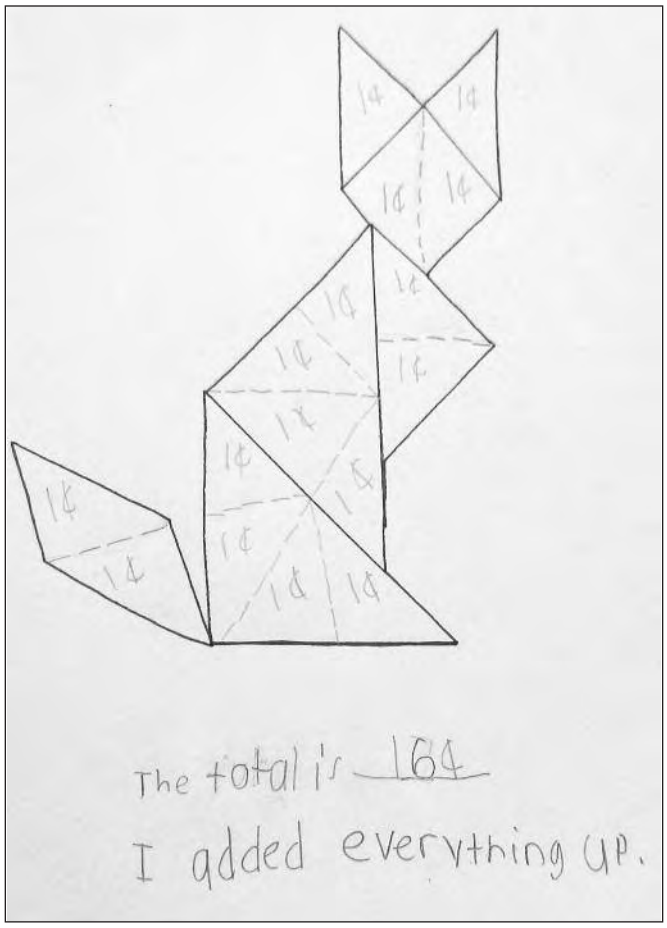
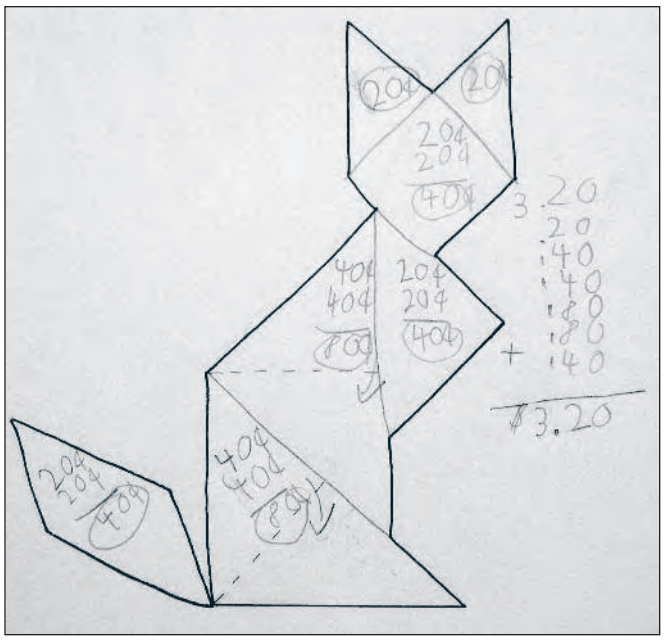


FIGURE 2: *Grade 3 Work Sample*



questions such "Where shall we begin?" "What do we know that can help us?" and probing questions such as "Can we approach this another way?" "Why?" and "How?"

The next step involved small and whole group reflection on this work (see Figures 1 & 2) and sharing ideas about how they obtained their solutions. Questions posed by the teachers included:

- What was your answer and how did you get it?
- Did you solve the problem in one or many ways?
- Did you and your child approach the task in the same way? If not, whose method did you use? Why? How did your methods compare?
- How did you help each other?
- What questions did you ask?

Teachers concluded this second family session by distributing paper tangrams and explaining a mathematics task for the families to do at home that extended the session's experience. This mathematics task involved having families create their own tangram design and find its cost, given another assigned monetary value for the smallest triangle piece of the tangram set. Material designed to guide the parent explorations with their children was distributed and parents were asked to bring all completed work to the third family session.

The main goal of that third session was to share the family work on the tangram problem given at the end of the last session (see Figure 3) and reflect together as a community of learners. To initiate reflection, teachers invited families to talk in small groups about their work on the tangram problem, using the same questions posed during the second family session about the nature of their collaboration.

At the end of the session, parents and their children were asked to write a reflection about their experience collaborating, with parents or a teacher scripting the thoughts of any younger children whose writing skills were not yet developed. These reflections, along with the written materials that families brought to the session, were collected at the end of the session.

MEASURES

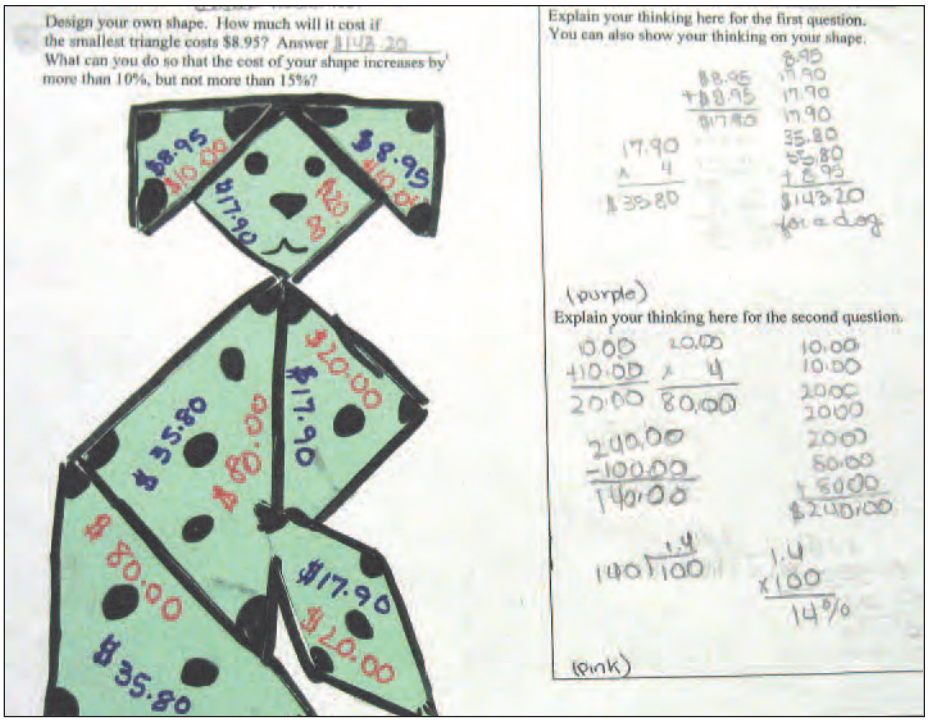
The ***parent survey*** (Mistretta, 2008b) consisting of 14 statements requiring 5-point Likert scale responses and one narrative response question served to investigate how the parents collaborated at home with their children in

mathematics and the challenges they faced. ***Work samples*** of assigned tasks done at home were graded with a 4-point rubric to assess the quality of work completed by the families. ***Written reflections*** served to identify student and parent feedback concerning the most enjoyable and challenging aspects of their collaboration.

To keep a written record of their observations of parental assistance, the questions posed to children by parents, and the verbal communication among the families, teachers took ***field notes*** during small and whole group discussions and while observing the parents and children working on their tasks.

A ***journal*** consisting of four entries was kept by each teacher throughout the professional development program. This was used to assess and monitor initial perspectives of teachers about parental involvement, reactions to the findings from collected data, and their developing perspectives about parental involvement and their role in cultivating it. More specifically, the first entry required the teachers to write about their perspectives concerning parents' interest in and commitment to collaborating with their child, their willingness as a teacher to include parents in their children's mathematical learning, and any practices they currently implemented to include parents in their child's learning of mathematics. For the second journal entry, the teachers used their findings from the parent survey to describe what they had learned about what parents do most and least concerning their child's mathematical learning and any challenges parents face helping their child with mathematics. The third journal entry focused on using the field notes collected during the second family session to focus on the following: Describe the interaction you observed between the parents and children as they worked on tasks together; Describe the responses you heard during the discussions as families worked on tasks together; and Have these observation or responses informed your understanding of parent-child collaboration and your related instructional practices? If so, how? The fourth journal entry centered on the third family session and required the teachers to use their collected work samples, field notes collected during this session, and written reflections at the end of the session to respond to the following questions: What scores did most families achieve on the home mathematics task? Have the work samples (solutions and solution strategies) informed your understanding of parent-child collaboration and related instructional practices? If so, how? Describe the responses you heard during the discussions. Describe the enjoyable and challenging aspects stated in the written reflections. Has any particular solution, method of solution, or responses during discussions informed your understanding of parent-child collaboration and related instructional practices? If so, how?

FIGURE 3: Grade 7 *Home Activity*



Four ***group interviews*** with teachers were conducted and audio-recorded during each teacher workshop using questions that reflected those of the journal entries. Notes were transcribed afterwards and compared with each teacher's corresponding journal entries to assess consistency between their journal entries and interview responses as well as clarify any unclear responses in either the journal or interview.

Data Analysis

Each teacher analyzed the data concerning their classroom families. They tallied the parent survey Likert-scale responses and scores

from their family work samples. They conducted content analyses on their parent survey narrative response question, field notes, and written reflections. Survey narrative responses were coded and tallied to determine emerging themes. Field notes and written reflections were coded and tallied to note trends in both the observed parent-child interaction and the written reflections from parent and their children. These data were also analyzed by project staff to ensure consistency of findings. In addition, teachers' journal entries and transcribed notes from small group interviews with teachers were coded and tallied by project staff to determine and compare emerging themes.

Discussion of Findings

After analyzing the teachers' first and second journal entries and related interview responses, it was clear that each teacher noted that at the onset of this project there seemed to be limited discussion between parents and children about how answers to mathematics problems are obtained. Teachers each indicated that most parents involved themselves in only checking that homework was done and reviewing for upcoming tests. Such limited parental involvement may have been a consequence of the teachers themselves unintentionally limiting parent involvement.

For example, all of the teachers initially acknowledged the value of involving parents, yet expressed a lack of confidence in the mathematics content knowledge of their parents. As a result, they each indicated their decision to give parents tasks they felt they could do—checking homework, reviewing for tests, and drilling multiplication tables. In addition, communication with parents about the mathematical learning going on in their classrooms consisted only of written letters focusing on classroom procedures such as when homework is given and how grades are calculated.

On a more positive note, the teachers' desire to learn how to more effectively involve parents in their child's learning of mathematics was evident. They all admitted they underutilized parents because they viewed their parents as not having the educational background to help their child, and didn't know how to alleviate the situation, but wanted to know how to involve parents more productively. This admission of and willingness to move away from the "deficit model" of parents previously described by Civil & Bernier (2006) provided an opportunity to develop new understandings of what it might mean to engage parents in the mathematics learning of their children.

When analyzing the narrative responses to the parent survey question, the teachers noted that parents referenced their lack of content knowledge and differing prior learning environments as reasons for their limited mathematical discussion with their children at home. The teachers each noted that the majority of their parents made comments such as "Mathematics today is taught differently than in my time. I don't want to confuse my child."

The teachers, in their third journal entry and related interview responses, each noted the benefits of engaging families in mathematics tasks in their own classrooms. They each viewed this setting as a means for building parents' content knowledge and understanding of "why we teach the way we do." They each acknowledged, as well, the usefulness of their recent opportunities to observe the forms of interaction between parents and their children and, at times, offer appropriate guidance. For example, one fourth grade teacher stated the following:

> "I see the need for me to help my parents realize it is essential to talk about math problems with their child even though they themselves may have struggled as a math learner. I have to encourage my parents to try and understand how their child arrives at their answers even though they themselves may approach the problem differently. I need to guide them to better understand how their child thinks so that they can productively help them."

These words merit recognition since they surface a realization of the need for teachers to support parents' efforts to better communicate with their children. A more focused lens on the specific words "I have to encourage my parents to try and understand how their child arrives at their answers even though they themselves may approach the problem differently," suggests the need for teacher educators to better prepare teachers to encourage connections between a variety of methods of solution. For example, when teachers facilitate communication within families about how differing methods compare and contrast, the approaches of both child and parent are recognized and valued, as opposed to one approach being viewed as inferior to the other. This type of communication among parents and children not only builds appreciation for diversity in

methods of solution, but also supports the scaffolding approach (Vygotsky, 1978; Wood & Middleton, 1975) by linking multiple approaches to build deeper meaning for the child.

An encouraging moment for the teachers was when they each noted their parents transitioning from a role of telling to one of listening and guiding. Most of their parents initially took control of conversations in an explanatory manner, using only one method of solution (theirs), and posing short answer questions requiring a yes/no or a number response. As the family sessions progressed, each teacher witnessed parents' receptiveness to their guidance and suggestions, and detected more meaningful collaboration starting to occur. For instance, parents began to question more and tell less by posing the prompting and probing questions offered by the teachers.

The teachers also noted how much their parents' enjoyed talking with their children about their thinking and conversing with other families about their successes and challenges. The children were also observed by each teacher as very willing to explain their thinking to their parents. For example, one first grade teacher stated the following:

> "The parents found the activities fun and wished they used manipulatives for math when they were in school. The parents had the opportunity to see how their child can reason and think. In the beginning, the parents were just giving the children the answers. When I told them the children had to explain how they arrived at their answer, they really listened and started to ask guiding questions instead of telling. This was a valuable experience for me because I saw how the families genuinely want to help their children with math and can if I properly guide them."

Experiencing this receptiveness, on the part of both parents and children, allowed the teachers to see the value in playing the role of catalyst for productive family collaboration.

The teachers' fourth journal entry and related group interview indicated that each teacher found most of their family scores on the home mathematics tasks to be 3 or 4, indicating accurate solutions and methods of solution. The following reflection from a second grade teacher indicates a realization that productive family collaboration on mathematics tasks can indeed be a productive undertaking:

> "The parents really wanted to be involved in the learning process and did great work at home with their child. I learned through conversations with them that they work late and by the time they arrive home they don't have enough time to go over the homework in a way they would like to. I therefore need to involve them in a project like we just gave them to do at home with enough time and guidance to do it."

Through the analyses of these home mathematics tasks, teachers realized that quality collaboration on mathematics tasks *can* happen at home when the proper support is given.

Each teacher, after analyzing the parent and child written reflections about the collaborative experiences, noted that most children appreciated the opportunity to share their own methods of solution that were often different from their parents' way of answering. For example, a fourth grade student made the following comment on the collaboration with her mother: "This was great; now she listens to what I think." The teachers also noted that most of their children said they felt challenged when their parents asked them how or why they arrived at their answers, but this was helpful to them. For example, a fifth grader reported, "It was hard to say what I was thinking. It kind of hurt my head. But it did help me sort things out."

The teachers noted, as well, that most parents expressed an appreciation for being able to witness their child thinking, and viewed the time collaborating as an opportunity to build better understandings of each other. At the same time, most parents viewed listening and guiding their child's mathematical thinking as a challenge because they were used to telling their children the answers and how to obtain them. A parent's comment reflecting this point was "I'm starting to catch myself. I listen more now before jumping in. It's not easy though, but I'm getting there."

Conclusions

This professional development program, designed to support family engagement in mathematics, provided an opportunity for teachers to build parents' knowledge of mathematics content and pedagogy. But even more, it provided tasks and venues for the teachers to note the ways families collaborated and the reasons behind their actions. Teachers were able to witness the willingness of parents to collaborate with their children on mathematics tasks and activities. They were also able to witness the

extent to which children enjoyed sharing their mathematical thinking with their parents. As a result, the participating teachers gained a deeper sense of value for the role of parents in the mathematics learning of their children, and recognized the role they might play in supporting this parent-child collaboration. Teacher preparation as described in this paper warrants consideration. Civil & Bernier (2006) state that teachers can influence the success or failure of efforts that seek to change the ways parents participate in their child's education. If parents need to productively involve themselves in their child's learning, teacher educators need to focus their attention on preparing teachers with the knowledge and skills necessary to cultivate such involvement.

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