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Facilitating Effective Mathematical Teaching Practices in Preschool

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Abstract

Initial seeds for mathematics literacy are planted during early childhood. Children benefit when they are exposed to and provided with opportunities for math experiences that emphasize their holistic development and not just mathematics proficiency in isolation. This way of viewing and presenting mathematics to young children requires teachers who are equipped with strong mathematics teaching skills. This study examined a 21-hour professional development series for public school preschool teachers on early numeracy, geometry, mathematical reasoning, and teaching pedagogies. This professional development series aimed to help preschool teachers incorporate effective mathematical practices and increase their comfort level in teaching mathematics. Participants noted this professional development series impacted their ability to foster children's early numeracy development, engage in *math talk* pose questions that helped children process early numeracy, and contextualize early numeracy through stories and/or word problems. The study demonstrates change takes time, and the impact of this professional development series is dependent on preschool teachers' readiness and their perception of their teaching context needs.

Keywords: professional development, early childhood education, preschool teachers, preservice teacher education

Introduction

The focus of early childhood education, traditionally, has been to facilitate student learning and their discovery of who they are through play- and activity-based experiences (Graue et al., 2015; Haslip & Gullo, 2018). The National Association for Education of Young Children's (NAEYC, 2019) professional preparation standards and competencies for early childhood educators also emphasize the understanding of the whole child, the relationships with families and the community, and the ability to provide developmentally appropriate and meaningful programming. The development of all domains, not just subject area content, is highlighted in Standards 4 and 5 (NAEYC, 2019). Thus, the professional identity of preschool teachers tends to focus less on isolated academic skill pedagogy and more on the holistic, interdisciplinary nature of working with young children and their families embedded within their own developmental, cultural, and linguistic contexts. However, the emphasis has started to shift. Early childhood education has become less about learner context and more about academic learning outcomes. This is due to legislation and the adoption of national and state student learning standards (Brown, 2015). For example, the Every Student Succeed Act, the United States federal education law signed in 2015

(Office of Elementary and Secondary Education, 2020) mandates each state to measure students' literacy, mathematics, and science learning.

Early childhood education teachers select to teach preschool because of their love for the younger ages and the desire to shape young children's lives (Friedman, 2016). The presence of accountability on student academic learning, which may not align with preschool teachers' reasons for career choice, creates a challenge for teacher educators today. How can early childhood teachers' whole child development focus and children's academic learning be strengthened? This paper describes a professional development series on mathematics for public school preschool teachers with the aim of increasing their mathematical teaching competency and discusses the implications of the training on increasing the early childhood educators' comfort level in mathematics.

Literature Review

The changing climate of the early childhood education landscape due to the emphasis on children's academic readiness begs the question of what the focus of early childhood teaching should be, especially in the preschool setting. Prior research (e.g., Friedman, 2016; Kass & Miller, 2018) indicate early childhood teachers enter and stay in the teaching field because of their internal or altruistic factors, which include the desire to make a difference in students' learning, their love for children, and their natural talent or propensity for teaching. McKinlay et al. (2018) found that passion for the preschool age range, as well as play-based pedagogy, contributed to teachers' professional longevity in Australia's daycare program.

Preschool teachers report lower self-efficacy with teaching mathematics (Takunyaci & Takunyaci, 2014) and are less likely to focus on subject content areas than kindergarten teachers (Abry et al., 2015). Additionally, preschool teachers' attitudes toward mathematics tend to be negative or neutral at best (Baroody et al., 2006; Blömeke et al., 2019). Research (e.g., Bates et al., 2011; Beilock et al., 2010) indicate those with low mathematics self-efficacy also experience mathematics anxiety and will tend to have less mathematics training. However, specialized mathematics training can impact in-service teachers' anxiety about teaching mathematics (Patkin & Greenstein, 2020). Blömeke et al. (2019) recommend "investing time during preschool teacher education in providing prospective teachers themselves with enjoyable and successful experiences of mathematical activities" (pp. 516-517). Thus, positively impacting early childhood educators' personal and pedagogical perception of mathematics at the pre-and in-service levels is needed.

Organization for Economic Co-operation and Development (n.d.) refers to the term, *mathematics literacy*, which describes an individual's capacity to understand and engage in mathematics to meet everyday life needs. This mathematical engagement is not about proficiency in certain areas of mathematics, but it is about using mathematical thinking to support decisions that a person encounters during everyday life.

Initial seeds for mathematics literacy are planted during the early childhood period. Those seeds, if nurtured appropriately, can turn into strong roots for children. Children benefit when they are exposed to and provided with opportunities for math experiences that emphasize their holistic development and not just mathematics proficiency in isolation (NAEYC, 2020). This way of viewing and presenting mathematics to young children requires teachers who are equipped with

strong mathematics teaching skills. However, not all early childhood teachers may be equipped with these skills; their mathematical identity may not be strong as they are prepared to be generalists in all subject disciplines. Most mathematical conversations, in U. S. preschool settings, are clustered around arithmetic (Lee & Ginsburg, 2009). Preschool teachers, like many parents, tend to focus more on the sequential counting of objects in their interaction with children. Teachers' intentional practices and capacity to attend to the subject area needs of children require content knowledge and knowledge of effective practices (McCray & Chen, 2012). Prior studies (e.g., Cantürk Günhan, 2020; Ozben & Kilicoglu, 2021) have demonstrated that pre-service teacher candidates' beliefs affect their attitude toward mathematics. Preschool teachers who personally enjoy and have an interest in mathematics tend to be more sensitive to opportunities for mathematical learning during children's play (Anders & Rossback, 2015). Therefore, teachers' capacity to create mathematical learning opportunities with an integrated approach requires an interest in mathematical exploration activities and some level of content and pedagogical knowledge. Studies also indicate the interactions teachers have with their students foster development and learning in children (Hatfield et al., 2016; Rhoad-Drogalis et al., 2018; Yoshikawa et al., 2013); thereby, making preschool teachers' role critical in shaping children's early mathematical learning.

Early childhood teachers choose early grades, especially the preschool level, because of their passion for this specific age range (Friedman, 2016; Kass & Miller, 2018; McKinlay et al., 2018) as well as the focus on the whole child and holistic development, not isolated subject area learning (NAEYC, 2020). However, increased emphasis on academic skills in mathematics and reading as early as the preschool level (Bassok et al., 2016; National Education Goals Panel, 1991) and a lack of positive perception of mathematics for early childhood educators (Bates et al., 2011; Beilock et al., 2010) alludes to the need for rich positive mathematical experiences that would help teachers embrace teaching mathematics (Anders & Rossback, 2015; Blömeke et al., 2019; Hatfield et al., 2016; Patkin & Greenstein, 2020; Rhoad-Drogalis et al., 2018; Yoshikawa et al., 2013). Thus, professional development opportunities in mathematics tailored toward preschool teachers' needs are warranted.

Methods

We designed a professional development series intended to promote preschool teachers' competency in early mathematics content and teaching in their classrooms and were the trainers of this series. The professional development content and format addressed our experiences with pre- and in-service early childhood teachers and anecdotal reports of early childhood teachers expressing the need for more math competency as well as their fear of math. This professional development series was offered through one of the five Early Childhood Regional Training Centers. Each Regional Training Center serves a specific region of Kentucky. The Regional Training Center sent the information about the training to public school districts within the boundaries of its service area.

A total of 62 preschool teachers representing 27 school districts commenced, and 46 out of 62 participants completed the three full-day training on early mathematics in the Fall of 2018. These teacher participants taught in classrooms that had either 4-year-old children who were deemed eligible for state-funded preschool due to family income at or below 160% of the federal poverty level, or 3- and 4-year-old children who qualified due to their identified developmental delay

(Commonwealth of Kentucky, 2020). We explained our wish to learn from the participants the impact of the training, the components of the study, and their right to choose to be a research participant or not for all, part, or none of the components as well as the freedom to change their minds per IRB approval on the first day.

The series consisted of three 8:30 am to 3:30 pm Friday sessions. Before the first session, an email was sent to the registered preschool teachers requesting they videotape a maximum of five minutes of how they engaged in mathematics with their students. A review of the 21 submitted videos demonstrated that the majority of teachers focused on rote counting and number identification. This video analysis confirmed as well as informed the development and implementation of the three-day professional development series based on Darling-Hammond et al.'s (2017) work on effective characteristics of professional development for teachers' principles. Specifically, four of the seven attributes: 1. focus on content, 2. active learning opportunities, 4. use of models and modeling, and 6. opportunities for feedback and reflection were central to the three sessions. Each training was structured around core mathematical ideas and effective mathematics teaching practices. See Figure 1 below for a summary of the mathematics and pedagogy focus that was presented each day.

The format of each training session consisted of three components modeled from Darling-Hammond et al.'s (2017) main characteristics of effective professional development, professional development activities and content materials from high-quality resources such as Stanford University's Development and Research in Early Math Education modules and utilized major research findings from the Cognitively Guided Instruction principles (Carpenter et al., 1996). As indicated in Figure 1, the training provided a clear content focus, opportunities for active learning, and modeling of effective teaching practices. Throughout the development series, the trainers introduced and explained topic content or core ideas to increase or enhance teacher participants' content knowledge. The participants, then, were provided time to apply content or core ideas during the second component. The teacher participants completed a variety of support activities from the perspective of adults and children. Each session also included a review of pedagogical implications and connections to literacy, as well as student learning standards. The participants were provided with a resource book, *Young children's mathematics: Cognitively guided instruction in early childhood education* by Carpenter et al. (2017) which was referenced and used throughout the training. This book was selected because it was based on Cognitively Guided Instruction principles and emphasized using children's thinking as a foundation for any instructional decisions (Carpenter et al., 1996). It included a myriad of support resources including manipulatives, mathematical materials, and children's books. Having modeled these during the training, each participant was then able to take these materials, books, and manipulatives back to their classrooms to use with their students.

During the series, the participants were given *homework* assignments to complete between sessions. These *homework* assignments consisted of reflective application activities that pertained to the session topics and the participants were tasked to implement this *homework* with their students. The authors intended these *homework* assignments to provide opportunities for the participants to apply strategies and activities learned during the session with their students. These homework assignments created an opportunity for feedback and reflection. The in-class artifacts produced from these homework assignments aimed at facilitating evidence-based conversations structured around specific experiences. At the end of the last session, participants reflected on their

learning as well as the overall effectiveness of the professional development series via a survey. The survey consisted of 10 closed-ended Likert-scale questions focusing on items described in Table 1. End of Training Surveys Summary, 3 open-ended *Please complete the sentence* questions, and one *Any other comments* question.

Figure 1. Professional Development Content and Pedagogy Focus

	Content focus	Effective Pedagogies	Literacy Connections
Early Numeracy Day 1 (mid-September)	Core counting principals and early number sense	• Pose purposeful questions • Use and connect mathematical representations	Book selection criteria: Which books are engaging and provide richer contexts
Opportunity for feedback and reflection "homework" assignments ***Implement*** the activities … and reflect on this experience by using questions provided in your book … ***Choose*** one activity from today's session to ***implement*** in your classroom as a whole group. If possible, also implement in small groups THEN ***reflect*** on the experience by discussing: (1) Types of higher order questions you asked during the large group to help children mathematically (2) Minimum two types of mathematical concepts that emerged from your large group discussion. Name and provide evidence for these two concepts			
Early Numeracy Day 2 (Early November)	• Subitizing and structuring numbers within ten and beyond 10 • Contextual problems • Children's levels of thinking	• Number talks • Models and tools	Story contexts for building meaning for addition and subtraction
Opportunity for feedback and reflection "homework" assignments **Pose** the same problem to three kids- take a picture of their solution and describe their solutions strategies. Use the terminology we developed in the session **Create story problems** with your kids in your class and have your kids act it out. **Implement** one of the activities we did today THEN **reflect** on the experience			
Early Numeracy Day 3 (Early December)	• Repeating and growing patterns • Patterns developmental trajectory • Matching and sorting • 2-dimensional and 3-dimensional shapes	• Developing early algebraic reasoning • Constructing viable arguments	Story contexts for pattern explorations
Opportunity for reflection "end of training survey"			

Additionally, four randomly selected preschool teachers were interviewed the following Spring 2019 semester. Thirty-four of 62 participants consented to have their names included in the interview selection pool. Eleven teachers were selected using the excel random function, and an invitation to interview email was sent. Ultimately, interviews occurred with only four of the 11 invited who did not have any scheduling conflicts or withdraw their initial consents. The final four interviewees consisted of one first-year teacher and three veteran teachers who had more than 10 years of experience. The first-year teacher was assigned the pseudonym, Kay. The three veteran teachers were named Angela, Bailey, and Elizabeth. The purpose of the interviews was to learn more about the impact of the training series on the participants' teaching practices in the classroom. These interviews ranged from 20 to 40 minutes and were conducted in a semi-structured format with the following common questions:

- What would you say is your overall learning takeaway from the training?
- How would you describe what a good mathematical discussion would look like in a preschool classroom?
- How do you think you can make mathematics more concrete and accessible for the children in your preschool classroom? How do you think you can accomplish that in your current teaching?

The prompts listed above provide a general direction, and we followed up with prompts like *can you give examples from your classroom*. We designed a semi-structured interview because we were more interested in how our participants personalized the content to meet the needs of their students.

Analysis

The main data source used to evaluate the impact of the professional development series on participating teachers' practices were the end-of-training surveys and semi-structured interviews. Descriptive statistics were used to summarize quantitative components of the end-of-training survey, and qualitative components of the end-of-training survey and interview data were examined for common themes. Because of the nature of the data we collected from our survey and the interviews, descriptive statistics, and qualitative analysis for descriptive purposes (Creswell, 2003) worked the best for our purposes.

Findings

Data collected from the end-of-training survey demonstrated the professional development series positively impacted many of the preschool teacher participants as summarized in Table 1 below.

Table 1. End of Training Surveys Summary

Item Focus		***%*** **(*Max n* = 46) ***
Training series impact	Helpful for teaching	72 (33/46)
Increase in	Comfort level in teaching early numeracy	83 (38/46)
	Knowledge level of early numeracy	84 (38/45)
Increase in competency level for	Contextualizing early numeracy through stories and/or word problems, development.	57 (26/46)
	Engaging in *math talk*	70 (32/46)
	Posing questions that help children process early numeracy, and	67 (31/46)
	Observing children to determine how best to foster children's early numeracy	73 (33/45)
The most applicable aspect of the sessions	Specific content focus such as story problems, math in literacy (using books/stories to teach math concepts), geometric reasoning (identifying and defining attributes of shapes), and number sense	72 (33/46)
	Materials received at the end of each session	78 (36/46)
	Homework assignments	36 (16/45)

*Number of responses changed for each item.

For the open-response *Please complete the sentence* question: *The strategies I found most applicable to my teaching from this training series is/are* participants noted how they found core counting principles, representing numbers in multiple ways, ordering numbers by using tools such as number line, instructional activity examples such as Mr./Mrs. Measure, and using rekenrek to build and compare numbers, higher-order questioning examples, ways to contextualize math, and integrate math into other disciplines as applicable pedagogical conversations were useful for their teaching. The participants also reported having the opportunity to work with the materials they received in each session before taking them back to their classroom to implement them with their students helpful.

Participants also commented on the active learning component of the training sessions. Although some participants found this active learning component useful, some participants commented such as *seasoned teachers, we didn't need so many examples of each activity,* and *the content was more appropriate for new teachers*. There was also criticism of the number of days and the homework assignments assigned at the end of each training day, such as how the content covered during the three-day session could have been delivered in one and a half or two days may help explain the lower applicability rating for the *homework* assignments.

For the open response *Please completed the sentence* question: *The content that I found most difficult during these three-day training sessions was/were*, participants' responses included geometric shapes, algebra, story problems, and literacy content. However, *statements such as how to modify activities for lower level/special needs students* and *creating different types of story problems [because] I tend to default to the easier ones* suggest, the difficulty may not be with the content but in how to apply the content knowledge in the classroom at their children's developmental level.

to the open response *Please complete the sentence* question: *What I wish there was more of is*, emphasized the need for more teaching pedagogy strategies on how to provide content in a developmentally appropriate way, integrate math with other subject areas (e.g., literacy), and facilitate learning of struggling children.

Despite the generally positive rating by the participants on their competency, comfort, and knowledge level as noted in Table 1, 26% (12 of the 46 participants who completed the survey felt there was too much focus on a higher level of mathematics. For example, some teachers expressed concern about the transferability challenge of the training series content to their classroom children who are considered *at-risk* and have developmental delays.

Interview Analysis

The interviews with the four teachers indicated three themes:

1) Mathematizing everyday activities,
2) Supporting children's mathematical learning using concrete materials, and
3) Differentiating for children's varying mathematical levels. However, experienced teachers appear to have internalized and implemented mathematical content from the training sessions more than the beginning teacher.

The beginning teacher, Kay, noted how much she appreciated the content from the training series, but she was not able to implement as much as she would have liked due to classroom behavior issues:

> I felt like when we went to the training, we had so many activities and cool things to do but I haven't been able to implement it in the classroom. …. We have two pretty big classes. We have a lot of IEPs so I'm putting out fires and doing classroom monitoring. I attempt to put it in there, but we just can't sometimes.

However, Kay shared how she became more intentional in her interaction with children and in how she attempted to meet different children's mathematical needs:

> Coming back and seeing how kids are and being able to differentiate instruction more….

> Changed my dialogue with kids when I'm differentiating…. I found I could talk to them more appropriately. Before, I felt like I was going above their heads or so below that they were not interested. I am more intentional now.

Like Kay, the other interviewees also commented about the change in the engagement of their children when mathematical opportunities were introduced. The three veteran teachers noted how they engaged in *math talk* more frequently with her children after the training series. They also appreciated having concrete and ready-to-go materials, received from the training, in the classroom as it made math implementation much easier. Elizabeth's statement below summarizes the impact of the training series:

> What I really liked about the training and what I took away was the fact that each time we did the training, we got the material and then we got the lesson to work with the materials and then we took it back…. as a result, I was able to do a lot of the activities as soon as I got back…. I started watching the kids as they counted…. I've tried to let them show me how they felt comfortable and then sometimes I would make suggestions, sometimes I wouldn't if they were successful with those strategies.… I also tried using quantitative, symbolic, and verbal as they did the math activities. Not just putting a number up there but putting up all three…. Another thing I took away from was that I never thought was the pattern types of things. I would just start by extending the pattern and then I would be frustrated. I notice now, because I am more aware, that they want to go ahead and put that on the red and then green, red, green and I would say, *oh wait a minute, no we are going to go on this way*. What I learned is that I should have let them try to copy it or even before copying it, just be aware of the pattern. So that was a big takeaway because I thought no wonder, I was so unsuccessful doing this because I didn't start back where they really needed to start back on. I realized that you can't just jump in. I also learned that story problems because I always shied away from them, that's something I found hard to teach so I enjoyed knowing about the different types, the joining and the unknown, and the change unknown, separating, the levels of part-part-whole. So that kind of gave me more of a basis to really analyze and look at where the child's level is.

Angela, another experienced teacher, shared how she was better able to understand how young children learn mathematics and added more intentionally planned mathematics activities throughout the day after the training:

> I feel that I learned a lot of activities and ways that children learn, from the child's perspective of learning math. I feel like I took away a lot of lessons that I have implemented into my classroom. For example, every day we do the *bubble gum, bubble gum, in a dish* during transition times. I started that out at my large group, and my kids really enjoy that.

However, when Angela was further asked to describe what she considered a good mathematical discussion, she alluded to using the bubble gum context (Parks et al., 2018) with her students again:

> Our transitions when we do the *bubble gum, bubble gum* and then if they pick a really big number, I say, *we count by 10 to get to that number* and then I use my fingers like each time when I say 10, 20, I flash 10 fingers so they can get an idea of how big that number is.

Thus, Angela took the training session ideas, especially those that resonated with her the most, and used the activities as is, rather than thinking about modifying the context to better fit the needs of her students. Mathematizing regular activities was a message emphasized in the three-day training, and the *bubble gum* activity (Parks et al., 2018) was an example of how to use an interesting context to make counting meaningful, fun, and concrete for children. Angela's use of the *bubble gum* activity (Parks et al., 2018) illustrated she understood the importance of mathematizing everyday activities messages from the training but appear to have difficulty knowing how to vary the context of her math talk in the classroom.

Angela also shared how she was supporting children's mathematical learning with concrete materials when she talked about how she and her children [c]*reated a number line … where we show representations of each number* and applied the *bear and cave* example activity from the training series in the classroom:

> I do the *Bear and Cave* activity, but I modified that a little bit. At small group, I put, for my lower group, four bears underneath the cave and say, *I'm going to lift it up really fast and see if you can tell me how many* so I kind of use that activity to see if they can subitize the numbers that they see or if they counted one-to-one correspondence.

During the training sessions, three aspects of a number (verbal, symbolic, and quantitative) were shared, and it was noted how important it is to incorporate quantitative aspects when building meaning for an abstract concept. The importance of multiple representations, as defined by the National Council of Teachers of Mathematics (2014), was also stressed and Angela took this idea and tried to incorporate that into her routine math activities. In these quotes, Angela is demonstrating her intention by bringing key mathematical ideas into classroom conversations and differentiating activities based on her students' needs.

Bailey, another veteran teacher, noted how this training helped her increase the mathematical expectations of her children and how she started providing additional challenges to support their learning:

> Incorporating math in the natural routine of the day. Also, just going a little bit more, an extension or a little bit above of what I know they know. Wherever they are on the developmental spectrum, just give them a little bit of push. If they didn't understand it or couldn't, it's okay. Just the time to give them opportunity instead of just saying, *oh, they are just three or four and they don't know that*. I just try to, especially with the reading problems you taught us about, I have done some of that too because that's just not something I really thought about to introduce to them. We do it together. Also, during center time as well, just to try to extend that a little bit or maybe question it a different way. Some of the higher-level equipment or toys or whatever you want to call it that you have provided for us to use that as well. The one thing that absolutely shocked me was the tangrams and the *Grandfather Tang* book. My first reaction was like *Oh, my gosh, this is too hard. They can't do it.* But what I did do was shorten the book. I didn't read it word for word with them. I just gave them the gist of the story and then I got out the magnet board and the tangrams and used my smartboard and just modeled and talked about how we can used different shapes to make different shapes to represent different animals or whatever we want. Just use our imaginations. I thought, *they just can't do this,* and they just went crazy with those things. I left it out on the table, and it was really a hot topic for a while. It's just amazing. You just think, *oh, they can't do that*. I have the two who I know can do anything and they could teach my class if I wanted to take off, but then you have the other ones and you are like, *oh so what if they made a house with it? Great. Wow. They figured that out.* They are composing shapes and decomposing shapes. I was so proud of them.

Bailey's comments stress her surprise at how much her children were able to grasp mathematical concepts, even mathematical content she considered high level for preschool-age children. Many of the geometric exploration activities (including tangrams) and exploring contextual problems (or so-called story problems) were considered as a *No* or inappropriate for preschool age by participants during the training series as illustrated in Bailey's quote about how she thought tangrams would be too difficult for her children. However, she was surprised or *absolutely shocked* to use her own words on how engaged her children were with tangrams to create animals.

The power of facilitating mathematical conversation through the use of questions and story problems as part of children's playtime was another *aha* moment for Bailey:

> I think it's asking a lot of different questions instead of asking just the ones that come to your mind. You are trained into asking, *how did you do that?* but to be more intentional and asking them to really count things out. I see that when they are playing in the house center, how many of that are there. Going back to your story problems, I have the magna tiles. They love the magna tiles. They get different counters. They are building aquariums, or they are building puppy dog houses. They add different colored animals, so I am thinking, *okay, if you have the three of the blue sharks and you have two of the red pufferfish, how many do you have altogether?* So, it's still doing the story problems, but not written out. It's just kind of joining their play where they are at instead of trying to take control of it and say, *I'm going to make this into a great math problem*. Just kind of seeing what they are doing and then from that, just dive right into their play so you are not taking away from their play.

Bailey began to see the benefits of mathematizing every day and developing mathematical understanding as part of a story problem play. She was able to apply content from the series, especially strategies such as posing questions and contextualizing mathematics, in her classroom to facilitate her children's mathematical learning.

The four teachers interviewed expressed an increase in their mathematics ability and in their competence in maximizing mathematics teaching throughout the day. However, not all of the four teachers interviewed felt comfortable or competent in integrating mathematics into their teaching at a deeper level. The interviewees cited having to deal with the challenging behaviors of children with special needs, having to meet the abilities of all the children in the classroom, and having to negotiate their own way of doing things as some reasons for their struggle.

In summary, the end-of-training surveys and interviews provide evidence of the 3-day professional development series having a positive impact on preschool teachers' ability and comfort in integrating mathematical practices in their classrooms.

Conclusions

Change in teaching practices or overall learning was mostly informed by teachers' self-report on surveys and interviews. The quantitative survey results revealed most of the teachers who participated in the three all-day professional development series on early mathematics did increase their knowledge and comfort level regarding early numeracy. The teacher participants, in general, also found the training sessions helpful for their mathematics teaching and reported that they applied the content they learned from the training sessions with the children in their classrooms. The qualitative responses to the open-ended questions on the survey, however, painted a less positive picture. About a quarter of the participants questioned the alignment of some of the content covered in the training sessions with their children who had developmental delays or came from at-risk backgrounds. The participants' comments demonstrated they felt some examples of the core content or core principles discussed in training sessions were more appropriate for children who were high-performing and thus not as realistic for their student's ability levels. Even though examples of teachers addressing children's continued mistakes and differentiating tasks for lower-performing children were presented, it did not resonate with many of the participants. The participants' desire for *material that was developmentally appropriate for at-risk/special needs/early childhood students* reflects preschool teachers' focus on Developmentally Appropriate Practice (DAP). An activity is determined to be developmentally appropriate based on its appropriateness to children's age, individual children, children's social needs, and culture (NAEYC, 2020). The participants' view that some of the content was only appropriate for high-performing children points to their need for more concrete examples of children who reflect the

range of abilities in their classroom, especially children with special needs. The need expressed by the participants for more concrete examples of training session content or topic core principles with children who have the developmental attributes of participant teachers' classrooms may also indicate preschool teachers' mathematics literacy and the conceptual understanding of mathematics level.

Several participants cited geometry (or in their words shapes) as one content that was most difficult; yet shapes or specifically *geometric shapes which bring in counting, shapes, and color* were also cited as most applicable to their teaching from the training series. The participants listed early algebraic reasoning as one of the most difficult topics for them (possibly due to the participants defining algebra in the traditional sense) and considered algebraic reasoning as too difficult or beyond the preschool level.

Comparisons were made between what was self-reported and what was demonstrated in the 5-minute math-activity videos the participants submitted before the training occurred and differences were evident. In the videos, all the teachers asked the children single-response questions and *gathering information* type of questions like *how many did you count?* or *what is this number (showing a numeral card)?* Whereas, from our interviews, teachers, especially Bailey, noted how she changed her questioning and started asking more of *how did you get that, why* and *bringing reasoning and justification* to the types of questions she asked. The other three teachers interviewed integrated the activities shared during the training series in their classrooms, even if the specific mathematical experiences for the children were the same activity from the training. Research (Lee & Ginsburg, 2009) indicates how early math work stays within the lens of arithmetic and the videos teacher participants shared before the training series confirm participants' emphasis on rote counting activities for their mathematics teaching Although their teaching practices did not change drastically, their old ways of doing mathematics did improve slightly through the incorporation of new strategies and intentional facilitation of experiences with specific mathematical concept goals for their students.

Recommendation for Early Childhood Teacher Education Programs: Lessons Learned

As previously discussed, the 3-day training series for practicing public school preschool teachers demonstrated an increase in their mathematical knowledge and comfort level. However, their perception of what was appropriate mathematics for all preschool children, especially those who are delayed, alluded to a need for a deeper conversation. One venue would be to integrate mathematics opportunities more during preservice teacher education by starting where the early childhood educators are. Early childhood teachers, especially preschool teachers, choose teaching at the preschool level for their love of children and the emphasis on the whole child, not necessarily a subject area content. For example, we, as the early childhood teacher education program faculty, frequently hear comments such as *I do not like Mathematics* or *I am not good at Mathematics* from the early childhood teacher candidates in their teacher education programs, echoing the negative or neutral association with teaching mathematics Blömeke et al (2019) noted in their research. This discomfort or dislike of mathematics content can translate into surface or initial level of mathematics learning process teaching or interactions in the classrooms. The surface or initial level understanding of the mathematics learning process consists of focusing more on the visible actions such as a child counting to 30 sequentially and not on the less definable actions such as a child could count by 5s or 10s, which is a more sophisticated way of counting to 30. Being able to see

beyond the simple rote counting and a child problem-solving counting 30 objects even while making occasional sequential number mistakes requires a deeper level of understanding rather than an oversimplification of children's numeracy learning process and resorting to what is common or typical in preschool classrooms.

- *Start from where teacher candidates feel the most strongly in mathematics.* Preschool teachers' mathematics teaching tends to focus on basic arithmetic, as evidenced by the participants' math videos they submitted as part of this study and as previously found in the literature (Lee & Ginsburg, 2009). During the training series, arithmetic activities such as *numbers on a clothesline* (Parks, 2015) were popular with all the participants. The teacher participants had to put a number on the number line in numeric order first and then create visuals representing each number. This number line activity was one of the items named by many of the participants in the survey as something that they found applicable to their teaching. Content such as early algebra and how facilitating meaningful mathematics conversations with children build foundations for early algebra was perceived as difficult and above the developmental level of preschool-age children by the teacher participants. Therefore, it is suggested to begin with an arithmetic activity of counting numbers but present a more enhanced version of counting numbers. The number line (Parks, 2015) activity allowed teacher participants to recognize the triangulation of number sense by beginning with the sequencing of numbers in a familiar and comfortable format and then moving to different formats. The deepening of teacher participants' mathematics understanding and new pedagogy could have been fostered if the authors had transitioned to story problems with the number line activity. For example, the authors could have asked the teacher participants to add visuals of animals increasing by one from one of the storybooks, *Rooster off to see the world* by Eric Carle, that was shared during the training. The act of teacher participants adding visuals from the storybook to their number line would have provided an opportunity for the teacher participants to dig deeper into the complexity of number relations.
- *Start with play-based activity exploration.* Darling-Hammond et al.'s (2017) noted the importance of active learning experiences in a professional learning setting. Our training sessions showed us that the teacher participants needed a safe space where they could simply explore and *play* with materials without any directives or time limit from the authors. They needed this time to process new information or known information at a different level. After the teacher participants *played*, the authors could then *model* the adult-child verbal interaction by posing questions that require problem-solving or reasoning responses and not simple facts at appropriate times and to appropriate groups of participants. These experience conversations with the authors and not just the teacher participants assuming the adult or child perspective would have created more opportunities for reflection, verbalization of concern or question about developmental applicability, as well as a description of the mathematical structure or concept behind actions. These as-needed interactions and conversations could also trigger examples of authentic differentiation or modification strategies.
- *Start from a DAP perspective*. New or familiar information must be connected to what teacher participants are currently doing with their children in their classrooms. One way to create relevant alignment is by reflecting on the mathematics content from the lens of DAP. Each mathematics experience can be examined from the three components of DAP: age-appropriateness, individual appropriateness, and social and cultural appropriateness (NAEYC, 2020). This process helps with an understanding of what and how of challenging preschool-

age children's processing and problem-solving of mathematics, regardless of their abilities or backgrounds. Because DAP is all about starting where children are and helping them, individually and as a group, to *reach challenging and achievable goals* (Phillips & Scrinzi, 2013, p. 2).

- Create a Space Allowing Sincere Participation and Providing Connected Experiences. A professional learning experience providing time for feedback and reflection (Darling-Hammond et al., 2017) in a space designed for genuine participation is essential. Given that 62 individuals participated in this professional development, it was hard to create sincere sharing sessions. At times, the trainers could not hear all the voices in the room, and this caused frustration for some participants. Third, there was a discontinuity in participants' experiences, and we did not follow up with people who missed parts of our training. For example, a person missing the second day and coming to the third day would have missed the conversation around the role and importance of contextual problems in making sense of operations and numbers, and on day 3, we referred back to those ideas and tried to build on what we did on day 2. Therefore, some of our participants had fragmented experiences rather than continuous ones. In addition, there were issues with the homework assignment artifacts. There was only a handful of participants who returned their homework assignments, those homework assignment artifacts included minimal information about what the teacher did. It was mostly pictures of students on task and teachers who turned in their homework assignments that brought those up on the day of training and that prevented any prior preparation for a conversation structured around those specific artifacts. Finally, the scheduling of these training days was not ideal for our teachers. Ideally, we requested one-month apart training days, but all the issues associated with scheduling full-day training day 2 and training day 3 were too close. Now, reflecting on our experience with our teachers, we could have utilized 6-half day training instead of 3 full-day training sessions, especially with this group of participants. There was already a content barrier, and our teachers left our training days feeling exhausted and overwhelmed. All these logistical issues should be considered and planned in detail to maximize the impact of these professional development series.

It is essential to be able to create a safe space where participants are doers of mathematics with all the real struggles associated with doing mathematics and without a fear associated with making mistakes or with no hesitation to communicate challenges they experience along the way. In conclusion, beginning where early childhood educators are in mathematics and connecting the complexity of mathematics to the reason why they chose or choose to become early childhood educators will help strengthen their mathematics literacy and identity.

Limitations

There were two major limitations of this study. First, not all the participants in this professional development series were volunteers. Despite the voluntary rather than mandatory nature of participation in this professional development series, many teachers perceived pressure from their district leadership, making it difficult to create buy-in from the majority of the teachers. The self-reporting nature of the survey is a limitation that should be considered in terms of the generalization of the findings. When we talked about the impact of the study, it was based on teachers' perceptions of the impact of our professional development series.

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