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The effects of an intervention on adults' beliefs and self-efficacy for implementing numerical tasks with young children

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This paper describes a course attended by 30 graduate students in mathematics education, non-preschool teachers, that aimed to promote participants' knowledge of young children's development of numerical competencies. Prior to the course, participants held high positive beliefs towards children's engagement with numerical activities, but their self-efficacy was low. Findings indicated that mastery experience, mostly by repeatedly analyzing videos, and repeatedly designing tasks, afforded participants a chance to see how they were progressing and increased their self-efficacy.

Keywords: Adults' beliefs, adults' self-efficacy, mastery experience, numerical competencies.

Introduction

In recent years, there has been a growing emphasis on early childhood mathematics education and the professional development of preschool teachers (e.g., Tirosh et al., 2019). While this is commendable, young children spend much of their time at home with parents, grandparents, and other responsible adults. As such, increasing adults' awareness of their roles in promoting early numerical skills is important. In a previous study (Levenson et al., 2021) we investigated 91 adults' beliefs (none were early childhood educators) regarding supporting children's engagement with various numerical activities. Findings indicated that in general, participants had positive beliefs towards early mathematics.

The current study builds on that previous study by investigating a small group of adults who participated in an intervention aimed at promoting their awareness to and knowledge for engaging children with numerical activities. In this paper, we describe the intervention and present findings related to adults' beliefs before and after attending the intervention. In addition, we investigate their self-efficacy for engaging young children with numerical activities. Even if adults believe in the importance of their involvement and the importance of engaging children with numerical activities, they might not believe they are capable of doing so, and thus might avoid such activities.

Background

Studies of adults' beliefs regarding early mathematics have mostly focused on parents. Those studies found that while parents tend to agree that mathematics can be and should be promoted in the years before first grade (e.g., Missall et al., 2015), they also believe that engaging young children with mathematical activities is less important than engaging children with literacy activities (Blevins-Knabe et al., 2000). Not surprisingly, in that same study, parents also reported reading to their children more often than engaging them with mathematics activities. Whether during everyday contexts, such as carrying out household chores, or during more structured contexts, such as direct teaching, parents

reported helping their children learn language skills more than mathematics (Cannon & Ginsburg, 2008). Thus, it may not be enough to have positive attitudes and beliefs towards early mathematics.

In addition to a person's beliefs, studies have found that self-efficacy can also impact on a person's behavior (Bandura, 1986). Bandura defined self-efficacy as "people's judgments of their capabilities to organize and execute a course of action required to attain designated types of performances" (1986, p. 391). Self-efficacy was found to be related to the effort, persistence, and commitment one places in their actions (Allinder, 1994). Parents' self-efficacy to parent successfully was found to impact on their involvement in their children's academic domain (Hoover-Dempsey et al., 2001), even at the preschool level (Pelletier & Brent, 2002). According to Bandura (1997), there are four main sources for a person's self-efficacy: mastery experience, vicarious experiences, verbal and social persuasions, and emotional and physiological states. The most powerful source is mastery experience; when a person completes a task successfully and deems the effort to complete that task worthwhile, that person's confidence to complete similar tasks will rise. In studies of teacher self-efficacy, this source has been found to be very influential (Arslan & Bulut, 2015). After mastery experience, vicarious experiences also impact on one's self-efficacy. A person gauges their success at a task by comparing themselves to others with similar abilities or attributes, who have engaged in the same task. The third source, verbal and social feedback, is considered weaker than the first two, although people do tend to see themselves through the eyes of others. Finally, the last source of self-efficacy is based on how people interpret affective states such as anxiety and mood.

Related to this study is how interventions can impact on self-efficacy. In one study, parents' self-efficacy increased after participating in an intervention that helped them focus on their children's strengths, as well as their own parenting strengths, while practicing new parenting skills (Waters & Sun, 2016). In another study, parents and their preschool children attended a school-readiness program where parents interacted with their children and observed teachers interact with their children (Pelletier & Brent, 2002). Findings indicated that parents' self-efficacy related to their own ability to teach and motivate their child increased. Parents reported that having the opportunity to interact with their child along with teacher support, impacted on their self-efficacy. Thus, mastery experiences and social feedback were sources for self-efficacy. For pre-service mathematics teachers, a methods course that involved group work when learning how to implement challenging tasks, served as an intervention that raised participants' self-efficacy through vicarious experiences (Yurekli et al., 2015).

The current study and intervention were based on the Cognitive Affective Mathematics Adult Education (CAMAEE) Framework (Levenson et al., 2021). The framework considers knowledge adults need for engaging children with playful mathematics, including knowledge of content and children (e.g., knowing that children aged three may not yet have acquired the cardinality principle of counting) and knowledge of activities that can promote numerical thinking. The framework also considers accompanying beliefs. In our previous study, we found that adults believed in the importance of their own intervention for promoting children's numerical knowledge, yet significantly less participants believed that they needed guidance to do so (Levenson et al., 2021). Furthermore, no differences were found between parents, adults who have some other connection with young children, and those who claimed to have no connection with young children. In that study, self-efficacy was not investigated. In the current study, we investigate the beliefs and self-efficacy of

adults prior to and after participating in an intervention aimed at promoting their awareness and knowledge for engaging children with numerical activities. Our research questions are: (1a) To what degree do adults hold positive beliefs towards promoting numerical skills in early childhood and (1b) believe that adults' interactions with young children are important? (2a) What are adults' self-efficacy beliefs regarding knowing children's numerical skills and (2b) what are their self-efficacy beliefs regarding designing numerical activities for young children? (3) How might a course that aims to promote adults' awareness and knowledge for promoting young children's numerical skills impact on adults' beliefs and self-efficacy?

Method

Participants and setting

The setting for this study was an elective course entitled *Early childhood numerical thinking: Theory and research*, attended by students working towards their master's degree in mathematics education. There were 30 participants (not the same as in our previous studies), of which twelve were parents of children between the ages of three and six, 13 had some other relationship with children of that age, and five claimed to not have any significant relationship with children of that age. None were early childhood educators. We chose this context for our study, wishing to include at this point in our research only adults who we hypothesized would have a general positive disposition towards mathematics. The aim of the course was to raise participants' awareness of number competencies developed prior to first grade, and in accordance with the framework, to increase their knowledge of children's development of those competencies, as well as the tasks that might promote early number knowledge and competencies.

The course included 13, 90-minute sessions, and focused on three major numerical competencies: counting and enumerating, comparing sets, and number composition and decomposition. During the first and last session, participants watched and then individually analyzed a video of Omer, a three-year old boy and his grandmother Esther (the second author of this paper), engaging in various counting activities while baking cookies. Analysis of this video, as well as other video clips viewed during the course, focused first on the child's ability to carry out the activity (e.g., Could the child count the cookies on the tray, and what were his difficulties?), as well as the adult's role in the activity (e.g., What exactly did the grandmother ask her grandson to do? How were the cookies arranged on the tray?). We will relate to this video and its analysis as the first activity (1) of the course. The rest of the course consisted of a series of activities repeated for each competency: (2) read and discuss related research (e.g., Gelman & Galistel, 1978; Tsamir et al., 2015), (3) view and analyze together YouTube videos of preschool children practicing that competency, (4) individually design a task to implement with a preschool child aimed at promoting that competency, (5) discuss together proposed tasks and agree upon one common task that each participant would carry out, (6) implement the agreed upon task with a young child while videoing the activity, (7) individually analyze the child's knowledge and competency when carrying out the task, (8) view and analyze together participants' videos. In accordance with the aims of the course and the framework, for each element of the course, we discussed children's ability to carry out a particular skill, as well as how a task may be designed and implemented to focus on a specific skill. For example, when discussing Tsamir et al.'s (2015) study of children's strategies for decomposing numbers, we discussed which strategies were more advanced and appropriate and how the task challenged children or supported a specific strategy.

Tools

A two-part questionnaire was handed out during the first and last sessions of the course, the first part focusing on beliefs and the second part focusing on adults' self-efficacy. A six-point Likert scale (1 being the lowest degree of agreement) was used to rate participants' agreements with the belief and self-efficacy statements. There were six belief statements related to promoting early numerical skills (see Table 1) and twelve self-efficacy statements, of which six related to knowing children's conceptions (e.g., I am capable of identifying different arrangements of 8 items which children find difficult to count) and six related to building appropriate numerical activities (e.g., I am capable of building activities that will promote children's skill in counting eight objects). Each group of six self-efficacy statements was combined to give an average self-efficacy score (see Table 2). Cronbach's alphas for each of the two categories was .924 and .965 respectively.

About a month after the course ended, participants were contacted and asked if they would agree to be interviewed. Twelve participants agreed, five parents of young children, four who had some other relationship with children, and three who had no significant relationship with young children. A semi-structured interview was conducted with the aim of identifying elements of the course that impacted on participants' self-efficacy for engaging young children with numerical activities. Participants were asked: The course focused on young children's numerical competencies. Which of the following elements of the course (here, participants were shown the eight course activities listed above) impacted the most on your self-efficacy for knowing about children and their ability to successfully carry out various numerical tasks? Which elements of the course impacted on your self-efficacy for designing tasks to promote early numerical competencies? Interviews were recorded and transcribed.

Findings

As seen in Table 1, and as we hypothesized, participants' beliefs regarding young children's engagement with number activities were positive from the start. At the end of the course, participants were even more positive. The only significant difference was noted for question 5. At the beginning and at the end, not all participants believed that every activity has the potential to invite children to engage with numbers. Yet, participants' belief in this statement on the posttest was significantly greater than on the pretest, perhaps due to the focus on activities in the course.

Table 1: Beliefs regarding engaging young children with numerical activities

Belief questions	Pre M(SD)	Post M(SD)	t(29)	p
1. Children enjoy activities/games that deal with number aspects.	5.23(1.006)	5.47(.819)	1.191	.243
2. Children's number knowledge can be promoted.	5.43(1.006)	5.77(.430)	1.836	.077
3. It is worthwhile to engage children with activities/games that deal with number aspects	5.70(.596)	5.87(.346)	1.306	.202
4. Activities/games that deal with number aspects can increase children's knowledge of number concepts.	5.67(.661)	5.70(.535)	.226	.823
5. Almost every activity/game can invite children to engage with aspects of number.	4.17(1.341)	4.70(1.264)	2.570	.016
6. Interaction between a child and an adult while engaging in an activity/game can increase the child's knowledge of number.	5.43(.774)	5.67(.547)	1.756	.090

While participants held positive beliefs towards children’s engagement with numerical activities, their self-efficacy at the beginning of the course was less positive, although not definitively low (see Table 2). As Michelle (all names are pseudonyms) said during her interview, “Before the course I thought I was aware and had a way (of doing mathematics with my child) and it was important to me.” By the end of the course, self-efficacy beliefs were significantly higher. Interestingly, their self-efficacy related to building numerical tasks was greater (although not significantly) than their self-efficacy for knowing children’s competencies.

Table 2: Self-efficacy before and after the course

Self-efficacy	Pre M(SD)	Post M(SD)	t(27)	p
...related to knowing children’s competencies	3.869(1.23)	4.869(1.008)	3.831	.001
... building numerical tasks	3.887(.802)	5.125(.802)	4.862	.000

Regarding elements of the course that impacted on participants’ self-efficacy, it was difficult for many participants to separate their self-efficacy for knowing children’s competencies and their self-efficacy for building numerical tasks. As they talked with the researcher, they intertwined both. This is not surprising as no significant differences were found between these two self-efficacy beliefs. Furthermore, building appropriate numerical tasks and knowing about students’ competencies go hand in hand. As Shur stated, “When I choose a task, like counting to 30, I need to know the age of the child, if he is 3, 4 or 5, and then I need to make a task for that child, for what that child knows, at his age.” Thus, below, we report in general how the various elements of the course seemed to impact on the participants’ self-efficacy for engaging young children with numerical activities.

Nearly all the participants found the video of Omer and Esther interesting. However, interesting does not impact on self-efficacy. What did impact on their self-efficacy was viewing the video twice, once during the first lesson and once during the last lesson. As Levy stated, “In the beginning, the story of Omer offered a taste, but did not help me know about what might be easy or difficult for children. But at the end of the course, ... then I could see how much I learned, that is, I could name the different competencies and say where he got stuck and where he didn’t.” Dahesh stated, “watching the video of Omer and Esther helped me see that maybe I could do those activities with cookies, and that I could build all kinds of tasks with different things.” In Levy’s case, we could say that the analysis of the video of Omer afforded him a mastery experience, seeing how much he had progressed at analyzing what a child can and cannot yet do. For Dahesh, it was a vicarious experience, seeing that someone else was able to do something led her to believe that she could do it as well.

There were several other activities where participants watched and analyzed videos – watching YouTube videos in class, watching videos they had made of themselves engaging children with numerical activities, and watching videos other participants had made of their activities with children. Regarding the YouTube videos, either participants did not mention this activity, or they specifically said that it made less of an impression than watching videos of themselves or of others in the course. Regarding the other two video activities, watching videos made of themselves was carried out individually as a home task, and watching others’ videos was carried out in a group situation. Interestingly, it was the context of the activity, doing it alone or as a group, which seemed to make a difference to some participants. For example, Dave remarked,

The main thing for me was the individual work, writing the summary of the activity carried out with the child...when you sit at home and watch your recordings, you concentrate much more... To me, the (numerical) activity seemed at first boring, and then you see that the child is having fun... I was always surprised that the child was having a good time.

For Dave, it was necessary to have the time and quiet to focus on a recording. Dave's feeling of surprise when he realized that the child was actually enjoying the numerical activities, hints at an affective impact. Salin emphasized the importance of the group setting, that it increased the opportunities to view different children engaging in numerical activities, "When you see each child that was videoed and the child's age, then I learned more what is easy or difficult for children." Michelle related to the discussion of the videos, and not just watching others' videos, "discussing the videos lets you see things from others' perspectives." All are relating to mastery experience, that is, their experiences in analyzing several children's engagement with numerical activities.

Another aspect of analyzing one's own videos was the fact that participants completed this task three times, one for each numerical content. Like Levy's comment that he was able to see the difference between his first and last analysis of Omer, Dave remarked on his analysis of his own recordings, "I could see my progress from the first analysis I did till the last. You can see it in the length of each analysis, that it increased...Each time I viewed the same recording and saw it again, that was real learning for me." Dahesh also referred to her progress when she analyzed each of her videos, "With each summary and analysis of the activity carried out with the child, there was improvement. The first summary was totally different than the last."

In addition to watching and analyzing videos, participants noted the activity of making up numerical tasks for children as an influential activity. This activity also had two parts, writing the task at home, and then discussing everyone's tasks in class and deciding together what to implement. Both parts seemed to impact on the participants. For Levy, building tasks and discussing with others their tasks, made him notice the specific components of various numerical competencies, which enabled him to address those components when building a numerical task, "In the beginning, I didn't know... that counting and enumerating are different competencies and they are different from composing and decomposing numbers, ... [Now] it's easier to focus each task I build and think in which direction I want to take the task." For Neta, discussing different tasks also had an affective impact, "The discussion [of different tasks] ... opened my mind to other ideas... and made me feel, wow, there are lots of important things [to consider]." Her exclamation of "wow," signifies an emotional response.

Less participants mentioned the importance of implementing the tasks with children. However, those that did stated that they were able to deal better with unexpected circumstances, such as asking a question in a different way when it seemed that the child did not understand directions. Neta stated, "such experiences increased my self-confidence to guide the child I was sitting with." She also stated that this part was "fun." The element least noted was reading research papers. Two participants asked to be reminded of which research papers were read during the course. It could be that as graduate students, participants had read so many papers and theories, that additional reading of research papers left less of an impression on them than other activities.

Discussion

As found in previous studies (e.g., Missal et al., 2015), participants in this study believed in the importance of promoting early number knowledge and believed that adults have an important role in this effort. Yet, before the intervention, adults' self-efficacy regarding knowing children's conceptions and building appropriate numerical activities was rather low. Perhaps this is one reason that previous studies (Cannon & Ginsburg, 2008) found adults engaged their children with more literary activities than number activities. That self-efficacy was rather low, contradicts finding from a previous study (Levenson et al., 2021), where adults believed their involvement was important, but did not necessarily feel they needed guidance. It might be that because all participants in this study were graduate mathematics education students, they realized, more than other adults might, that they did not have adequate knowledge for promoting young children's' mathematics knowledge. Further study is needed to investigate the self-efficacy of adults who do not have a mathematical background.

Regarding how elements of the course impacted on adults' beliefs and self-efficacy, in accordance with Bandura's (1997) theory, we found that mastery experience, mostly by repeatedly analyzing videos, and repeatedly designing tasks, afforded participants a chance to see how they were progressing. This finding leads us to conclude that short-term workshops may not be enough. One needs to accumulate positive experiences to feel that they have mastered a task and are able to carry out a task. We also found that it was not just one activity, but a combination of several activities, along with positive feelings of surprise and enjoyment, that resulted in higher self-efficacy. Previous studies have reported the benefits of supplying parents with mathematical activities to be done at home (Vandermaas-Peeler et al., 2012); this study has shown the benefits of having adults practice designing their own tasks to carry out with children. Furthermore, supplying activities might not be enough if adults do not have the self-efficacy to implement them. Watching videos of other participants' implementations and discussing those activities with one's peers, can lead to helpful vicarious experiences that may also boost self-efficacy. Further research is needed to investigate the impact of similar courses for adults who do not have a mathematical background.

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