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Shedding light on preschool teachers' self-efficacy for teaching patterning

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As teacher educators, we recognize the importance of considering teachers' self-efficacy for teaching mathematics. In this study, we investigate preschool teachers' self-efficacy for teaching repeating patterns, both before and after participating in a professional development program. Findings from questionnaires indicated that self-efficacy related to subject-matter knowledge changed little, while self-efficacy related to pedagogical-content knowledge, increased. Interviews with teachers shed light on these findings.

Keywords: Repeating patterns, self-efficacy, preschool teachers, professional development

Introduction

Recently, several countries have introduced specific guidelines for introducing mathematical concepts during the early years. Along with new guidelines comes a need for enhancing preschool teachers' knowledge for teaching mathematics. Knowledge, however, may not be sufficient. Teacher self-efficacy is another factor which may impact on teachers' classrooms interactions and student achievement (e.g., Guo, Piasta, Justice, & Kaderavek, 2010). Teacher self-efficacy may be conceptualized as "a teacher's individual beliefs in their capabilities to perform specific teaching tasks at a specified level of quality in a specified situation" (Dellinger et al. 2008, p. 752). With regard to mathematics, Hackett and Betz (1989) defined mathematics self-efficacy as, "a situational or problem-specific assessment of an individual's confidence in her or his ability to successfully perform or accomplish a particular [mathematics] task or problem" (p.262).

This paper focuses on preschool teachers' self-efficacy for engaging young children with repeating pattern activities. Repeating patterns are patterns with a cyclical repetition of an identifiable 'unit of repeat' (Zazkis & Liljedahl, 2002). For example, the pattern ABBABBABB... has a minimal unit of repeat of length three. According to the Israel National Mathematics Preschool Curriculum (INMPC) (2008), "patterning activities provide the basis for high-order thinking, requiring the child to generalize, to proceed from a given unit, to a pattern in which the unit is repeated in a precise way" (p. 23). In this paper we take a close look at a group of preschool teachers who attended the Repeating Patterns professional development Program (RPP) aimed at enhancing their knowledge and self-efficacy for teaching repeating patterns. We examine their self-efficacy before and after the program, and through interviews, we attempt to untangle variations in their self-efficacy beliefs.

Background

For the past several years, we have been employing the Cognitive Affective Mathematics Teacher Education (CAMTE) framework for investigating preschool teachers' knowledge and self-efficacy

for teaching mathematics, as well as planning for professional development with preschool teachers (Tirosh, Tsamir, Barkai, & Levenson, 2017). The framework is based on Shulman's (1986) recognition of teachers' subject-matter knowledge (SMK) and pedagogical-content knowledge (PCK), as well as Ball, Thames, and Phelps's (2008) refinement of these elements.

| Subject-matter | | Pedagogical-content | | |
|----------------|---|--|---|---|
| | Solving | Evaluating | Students | Tasks |
| Knowledge | Cell 1: Defining, drawing, extending repeating patterns | Cell 2: Identifying examples of repeating patterns | Cell 3: Knowledge of students' ways for drawing, extending, and comparing repeating patterns | Cell 4: Designing and choosing tasks for promoting and evaluating children's knowledge of repeating patterns |
| | Cell 5: Mathematics self-efficacy related to Defining, drawing, extending repeating patterns | Cell 6: Mathematics self-efficacy related to evaluating solutions | Cell 7: Pedagogical-mathematics self-efficacy related to children's conceptions | Cell 8: Pedagogical-mathematics self-efficacy related to designing and evaluating tasks |

Table 1: The CAMTE framework illustrated within the context of repeating patterns

Regarding teachers' knowledge of patterning, several studies pointed out the need to promote teachers' knowledge of the language of patterns. For example, Waters (2004), described how one preschool teacher showed the children dress materials with, what she called, patterns. Some of the materials contained a mixture of shapes, colors, hearts, and stars, and demonstrated random designs without any regularities. The teacher did mention the need for repetitions, but did not focus on what exactly is repeated. Similarly, in our study of preschool teachers' patterning knowledge (Tirosh, Tsamir, Levenson, Barkai, & Tabach, 2018), we found that teachers have difficulties verbalizing what exactly is repeated, although most referred in some way to the unit of repeat and to the notion of repetition. We also found that when asked to draw or continue repeating patterns, teachers mostly drew repeating patterns that have three cycles of the unit of repeat and a unit length of three. In addition, teachers' continuations of given patterns indicated a strong tendency to end patterns with a complete unit of repeat.

For each knowledge cell in the framework, there is a related self-efficacy cell, emphasizing teachers' mathematics self-efficacy as well as their pedagogical-mathematics self-efficacy, i.e. their self-efficacy related to the pedagogy of teaching mathematics (see Table 1). This differentiation was also pointed out by Bates et al. (2011), who investigated the relationship between early childhood (pre-K to third grade) preservice teachers' mathematics self-efficacy and their mathematics teaching self-efficacy. Results of that study showed that teachers who reported higher mathematics self-efficacy were more confident in their ability to teach mathematics than teachers with a lower

mathematics self-efficacy. However, participants with a high mathematics teaching self-efficacy did not necessarily perform well on the mathematics skills test. Some teachers who scored low on the skills test still felt confident to teach mathematics. We also note that self-efficacy beliefs are not only domain-specific (e.g. mathematics, history, science) and content-specific (e.g., within the domain of mathematics there is numeracy, patterns, geometry, etc.), but also task-specific (e.g., extending patterns, duplicating patterns, etc.) (Zimmerman 2000).

The aim of this paper is to report on preschool teachers' mathematics self-efficacy as well as their pedagogical-mathematics self-efficacy, before and after the Repeating Patterns Program (RPP). The teachers in this study met seven times (21 hours in total) over a period of about four months. All lessons were planned by the four authors of this paper. The fourth author did the actual teaching. The program revolved around patterning tasks that we designed, which teachers could implement with children, but could also be used to engage teachers with the mathematics involved in patterning, and promote their knowledge of patterning tasks and children's ways of solving those tasks. Towards the end of the program, teachers implemented patterning tasks with children in their classes, video-taped their implementations, and then brought those recordings to the program for discussion. (See Tirosh et al. (2017) for additional information regarding this program.) Specifically, we ask: (1) Was there a change in teachers' self-efficacy from before to after the program, and if so, what was the nature of this change? (2) When reflecting on self-efficacy, how do teachers explain their self-efficacy beliefs?

Methodology

Participants in this study were 18 preschool teachers enrolled in the RPP. All had a first degree in education, between 1 and 38 years of teaching experience in preschools, and were currently teaching children ages 4-6 years in municipal kindergartens. All sessions were videotaped and transcribed.

Before the program began, and again during the last session, teachers were asked to fill out a questionnaire which began with the following self-efficacy statements: I am able to say what a repeating pattern is; if shown a repeating pattern along with several suggestions for continuing the pattern, I am able to choose appropriate continuations; I am able to point out repeating patterns that most preschool children are able to continue appropriately; I am able to choose tasks for investigating children's patterning knowledge. A four-point Likert scale was used to rate participants' agreements with self-efficacy statements: 1 – I do not agree that I am capable; 2 – I somewhat agree that I am capable; 3 – I agree that I am capable; 4 – I strongly agree that I am capable.

Approximately one month after the program was over, seven teachers, chosen to reflect a variety of responses (e.g., no change in self-efficacy, increased self-efficacy, decreased self-efficacy) were interviewed individually. The aim of the interview was to further investigate teachers' self-efficacy beliefs for teaching patterning by evoking their reflections on these beliefs, and focusing on changes that may have occurred with regard to self-efficacy. In general, the interview questions were of the form: "Before the program began, you wrote that you strongly agree (somewhat agree/agree/do not agree) that you are capable of _____. At the end of the program you wrote _____. Can you tell

me more about this?” The blanks were filled in with the different tasks taken from the questionnaire and teachers’ self-efficacy assessments in the pre- and posttests. In addition, teachers were encouraged to freely reflect on their self-efficacy beliefs. Interviews were recorded and transcribed.

Findings

Results from the questionnaires

Table 2 shows the mean values for teachers’ self-efficacy scores before and after the program (on a scale from 1-4). As can be seen, teachers had a rather high regard, both before and after the program, in their ability to define a pattern and to choose appropriate continuations for a given pattern, with their self-efficacy rising slightly after the program. Teachers also had a high self-efficacy for identifying patterns that children could continue, with seemingly no change between before and after the program. The greatest change was noted in the last question. Before the program, teachers were not so confident in their ability to choose appropriate pattern tasks for investigating children’s pattern knowledge, whereas after the program, their self-efficacy was noticeably higher.

| | Self-efficacy statement | Pre | | Post | |
|-----|---|------|-----|------|-----|
| | | Mean | SD | Mean | SD |
| SMK | I can say what a pattern is. | 3.3 | .59 | 3.8 | .44 |
| | I can choose appropriate continuations for a repeating pattern. | 3.6 | .62 | 3.8 | .38 |
| PCK | I can point out patterns that most preschool children can continue. | 3.2 | .56 | 3.3 | .69 |
| | I can choose appropriate tasks for investigating children’s patterning knowledge. | 2.2 | .79 | 3.4 | .72 |

Table 2: Means and SD per self-efficacy statement before and after the program (N=18)

Taking a closer look at the distribution of self-efficacy scores, Table 3 presents the frequencies of teachers whose self-efficacy scores increased, stayed the same, or decreased.

| | Self-efficacy Statement | Increased | No change | Decreased |
|-----|--|-----------|-----------|-----------|
| SMK | I can say what a pattern is. | 6 | 12 | - |
| | I can choose appropriate continuations for a repeating pattern. | 5 | 13 | - |
| PCK | I can point out patterns that most preschool children can continue.* | 4 | 9 | 4 |
| | I can choose appropriate tasks for investigating | 12 | 4 | - |

| | | | | |
|--|------------------------------------|--|--|--|
| | children's patterning knowledge.** | | | |
|--|------------------------------------|--|--|--|

*One teacher did not respond. **Two teachers did not respond.

Table 3: Changes in self-efficacy beliefs between pre and posttests (N=18)

In general, approximately two-thirds of the teachers did not feel a change in their self-efficacy related to SMK, while the rest of the teachers' self-efficacy increased. However, when it came to PCK-related self-efficacy beliefs, findings were more complex. With regard to knowledge of students, approximately half of the teachers did not feel any change, but 25% of the teachers felt a rise in their self-efficacy and 25% reported a decrease. With regard to knowledge of tasks, approximately 75% of the teachers' self-efficacy scores increased, with the rest showing no change.

Interviews: Reflecting on self-efficacy

As seen in the previous section, most teachers' SMK-related self-efficacy beliefs were high and did not seem to change. When asked to comment on her SMK-related self-efficacy, Michelle (this and all other names are pseudonyms), who rated her self-efficacy both before and after the course at level 4, said, "Before the course, I don't think I knew how to define a pattern. I'm trying to remember when I learned this topic. But after we studied this in depth during the program...I know a lot more now." While Michelle does not explain why in the beginning of the course she had such a high self-efficacy, thinking back, she realizes that her SMK regarding defining a pattern actually increased.

With regard to being able to choose appropriate continuations to a pattern, Anne explains why she rated her self-efficacy as very high before the course, "Before the course, I knew that a pattern could be continued in several ways." However, she adds, "But now, I understand the reasoning behind these options, and I can explain it better to the children." In other words, although her self-efficacy rating has not changed, she feels that her knowledge has increased. Rina, who also had rated her self-efficacy as 4 both before and after the course, had a different reason for why no change was reported:

In the beginning of the course, when they asked me these questions, I think I didn't really know what they [repeating patterns] meant. At the end of the course, now, I understand what is meant by a repeating pattern, that it can end in the middle [with a partial unit of repeat]. Now, the question is clear. I don't remember what I wrote in the beginning.

In other words, Rina reflects back on before the course, and can now say that before the program, she did not really know what was meant by a repeating pattern, and was not aware that patterns do not have to end with a complete unit of repeat. This is similar to Michelle. Both teachers seem to acknowledge that their self-efficacy ratings in the beginning of the course were incorrectly high. In fact, when Rina was asked what score she should have given herself in the beginning of the course, she answered, "Now, I'm a 3-4. Then, maybe a 2, because I did know a little."

When it came to reflecting on their PCK self-efficacy beliefs related to knowing children's patterning abilities, teachers again had varied responses. Prior to the program, Anne had evaluated her self-efficacy at level 3, and at the end she reported level 4. She told the interviewer that her self-

efficacy increased and explained, “Today, I can define it [a repeating pattern] better. I know that there is a minimal unit of repeat, and that it is made up of elements. This definition organizes my thoughts and adds to my self-efficacy.” Although Anne was asked to relate to her ability to point out patterns that most preschool children can continue, her response focused on her ability to define a repeating pattern. It could be that for Anne, her knowledge of the centrality of the minimal unit of repeat, affected her belief in her ability to assess children’s knowledge.

Rina, who consistently rated her self-efficacy to assess children’s knowledge at 4, said, “If, in the beginning of the course, I didn’t really understand about repeating patterns, then of course, I couldn’t really know about the children.” Rina is acknowledging her over-confidence in the beginning of the course. Moreover, she connects her SMK with her PCK, by connecting her knowledge of patterns to her knowledge of students. Sharon, who consistently rated her self-efficacy at level 3 said, “I’m not so sure of myself here. I think I need more experience working with children to feel more sure of myself in this area.” This explains why currently, her self-efficacy is a 3 and not a 4. When asked to reflect back, she adds, “Before (the course), I would give myself a 2. I didn’t engage with patterns as much as I do now, and so I’m more self-confident now that I can do things better.” She now acknowledges that her self-efficacy in the beginning of the course was too high.

Lottie’s self-efficacy for assessing children’s patterning knowledge decreased from a 4 to a 3. During her interview, she stated the following:

For me, before the course, I would have children make patterns by giving them a red sticker, and then a yellow sticker, and so on. This course was a wake-up call. Patterns can be made with different materials... I was stuck on one type. There is also the pattern ABB. Before, I engaged the children with patterns, but without reflecting on what I did.

Lottie states that before the program, she engaged children with patterning tasks. This could be the reason that in the beginning, she felt very strongly that she could say which patterns children would be able to complete. After the course, Lottie acknowledges that her previous patterning knowledge was limited. Perhaps, this causes her now to be unsure regarding her knowledge of children.

Finally, we review teachers’ reflections regarding their self-efficacy for choosing appropriate tasks. Recall that most teachers’ self-efficacy for choosing tasks increased. Rina, who increased her self-efficacy from a 3 to a 4, commented, “I did work with repeating patterns with children, but they were not so varied, they did not end in the middle (with a partial unit of repeat).” Sharon, who went from level 2 to 4, said, “The program gave me lots of tools, and also self-confidence.” However, she qualifies her response by adding, “I think I still need more experience.” Similarly, Anne, who also went from a self-efficacy of 2 to 4, said, “The patterns that Ruthi (the program instructor) gave us in the course, really helped me to organize my thoughts and implement them in the kindergarten. I know that another teacher also uses them, and even when in the yard she uses sound patterns, because it’s very nice, and we really liked it.”

Summary and discussion

This study examined preschool teachers' mathematics self-efficacy as well as their pedagogical-mathematics self-efficacy, related to teaching repeating patterns, as well as teachers' reflections on these beliefs. Regarding teachers' SMK-related self-efficacy beliefs, results indicated that no significant change was felt. That teachers reported high SMK-related self-efficacy beliefs at the end of the program, was satisfying. However, we are left with two questions: How is it that teachers had such a high self-efficacy before the program began? In addition, even though the reported self-efficacy beliefs did not change, did teachers feel some change?

Regarding the first question, it could simply be that teachers indeed knew how to complete these tasks in the beginning, although to a lesser extent than they did in the end. In a previous study (Tirosh et al., 2018), we found that most preschool teachers did recognize that a repeating pattern must have unit of repeat, but missed stating that the unit must be structured. On the other hand, they could all construct and extend given repeating patterns. Regarding the task of choosing an appropriate continuation for a given repeating pattern, in general, teachers were able to choose appropriate continuations, although they had greater success in choosing appropriate continuations for the patterns which ended with a complete unit, than for the pattern which ended in a partial unit.

Teachers' interviews shed additional light on the issue of their self-efficacy. During the interviews, some teachers acknowledged that their first self-efficacy reports were higher than they should have been. They explained these initial high self-efficacy reports by saying that the topic of repeating patterns was not new to them. Thus, it might be that teachers did feel a change in their knowledge, but that this change was not reflected in the questionnaires. This finding raises the complexity of investigating self-efficacy beliefs. First, it could be that a scale of 1-4 was not sensitive enough to capture changes. In addition, this study, like most self-efficacy studies (e.g., Bates et al., 2011), relied on Likert-scales. It was the addition of interviews that revealed teachers' changes in their beliefs. Thus, we encourage the use of interviews when investigating self-efficacy.

Regarding teachers' PCK-related self-efficacy beliefs, from the questionnaires, it seemed that teachers did not feel a change in their self-efficacy related to knowing children's patterning abilities. Taking a closer look, we found that some teachers' self-efficacy increased, some stayed the same, and some teachers' self-efficacy decreased. As one aim of the course was to support teachers' self-efficacy beliefs, this result is surprising. One explanation is that after the program, teachers realized how much more there is to learn. They also mentioned feeling the need for more experience engaging children with patterning activities. Thus, this may actually be positive outcome of the program.

Regarding teachers' self-efficacy for choosing patterning tasks that can investigate children's knowledge, we ask, why is it that before the course this particular self-efficacy belief was relatively low? One possibility is that we asked teachers if they could choose tasks for the purpose of investigating children's pattern knowledge. It could be that if they were asked to choose tasks that had the potential to promote, rather than assess knowledge, their self-efficacy might have been greater. In a previous study of preschool teachers' knowledge and self-efficacy for teaching three-dimensional figures (Tsamir, Tirosh, Levenson, Tabach, & Barkai, 2015), we found that teachers'

self-efficacy related to designing tasks for promoting knowledge was greater than their self-efficacy related to designing evaluation tasks.

Finally, this study highlighted the connection between teachers' SMK-related self-efficacy and their PCK-related self-efficacy. When asked about her self-efficacy for knowing children's pattern abilities, Anne referred to her improved ability to define a repeating pattern. Rina and Lottie also connected their knowledge of repeating patterns, including that a repeating pattern does not have to end a complete unit of repeat, to their knowledge of children and patterns. While previous educators (e.g., Ball, Thames, & Phelps, 2008; Shulman, 1986) connected teachers' SMK to PCK, this finding connects teachers' SMK-related self-efficacy to their PCK-related self-efficacy, and suggests that if we wish to promote positive self-efficacy for teaching mathematics, we should also consider teachers' self-efficacy for solving mathematical tasks.

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