# Preschool teachers' knowledge and self-efficacy regarding counting and enumerating tasks[1]

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## 1 Introduction

The preschool teacher has an integral role in fostering children's mathematical abilities. "It is up to her to devote attention both to planned mathematical activities as well as mathematical activities which may spontaneously arise in the class and to pay attention to the mathematical development of the children" (Israel National Mathematics Preschool Curriculum [INMPC], 2008, p. 8). Yet, in Israel, as in many countries, attention to mathematics teacher education is mostly given at the elementary and secondary levels (Arcavi, 2004; Kaiser, 2002). All too often, preschool teachers receive little or no preparation for teaching mathematics to young children (Ginsburg, Lee, & Boyd, 2008). With this in mind, it is not surprising to find an increased call for strengthening the preparation of preschool teachers for teaching mathematics. The National Association for the Education of Young Children (NAEYC) and the National Council for Teachers of Mathematics (NCTM) recommend that "teachers of young children should learn the mathematics content that is directly relevant to their professional role" (p. 14). Similarly, the Australian Association of Mathematics Teachers (AAMT) and Early Childhood Australia (ECA) published a joint position paper recommending that early childhood staff be provided with "ongoing professional learning that develops their knowledge, skills and confidence in early childhood mathematics" (2006, p. 3).

This paper describes results from a professional development program, which aimed to promote teachers' knowledge necessary for teaching mathematics in preschool while also taking into consideration teachers' self-efficacy beliefs. The framework used to plan and implement the program was the *Cognitive Affective Mathematics Teacher Education (CAMTE)* framework. A description and rationale of the framework and how it was used in the planning and implementation of the professional development program can be found in a paper presented at this

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conference entitled, "Conceptualizing preschool teachers' knowledge and self-efficacy for teaching mathematics: The *CAMTE* framework" by Tsamir, Tirosh, Levenson, Tabach, and Barkai. In the current paper, we briefly describe the *CAMTE* framework and illustrate how it was used to investigate teachers' knowledge and self-efficacy related to counting and enumeration tasks.

## 2. The *Cognitive Affective Mathematics Teacher Education (CAMTE)* Framework

In framing the mathematical knowledge preschool teachers need for teaching, we draw on Shulman (1986) who identified subject-matter knowledge (SMK) and pedagogical content knowledge (PCK). We differentiate between two components of teachers' SMK: being able to produce solutions, strategies, and explanations and being able to evaluate given solutions, strategies, and explanations. Regarding PCK, we draw on the works of Ball and her colleagues (Ball, Thames, & Phelps, 2008), who differentiated between two aspects of PCK: knowledge of content and students (KCS) and knowledge of content and teaching (KCT). KCS is "knowledge that combines knowing about students and knowing about mathematics" whereas KCT "combines knowing about teaching and knowing about mathematics" (Ball, Thames, & Phelps, 2008, p. 401). The framework used in our program also draws on Bandura's (1986) social cognitive theory which takes into consideration the relationship between psychodynamic and behaviouristic influences, as well as personal beliefs and self-perception, when explaining human behaviour. Thus, besides investigating preschool teacher's knowledge it is important to relate also to their self-efficacy.

The design of our program and the accompanying study was based on the framework presented in the following 8-cell knowledge and self-efficacy matrix (see Table 1). In cells 1-4, and in cells 5-8, we address teachers' knowledge and self-efficacy respectively. In this paper we focus on Cells 4 and 8 with regard to counting and enumeration. The curriculum in Israel differentiates between reciting the counting sequence, henceforth called counting, and knowing how to count objects in a set, henceforth called enumeration. Gelman and Gallistel (1978) outlined five principles of counting objects. The three “how-to-count" principles include the one-to-one principle, the stable-order principle, and the cardinal principle. Two "what-to-count" principles include the abstraction principle, and the order-irrelevance principle. Knowledge related to Cell 4 and enumeration includes knowing how to design and evaluate tasks which may be used to foster children’s acceptance of the one-to-one

correspondence principle and the cardinality principle necessary for enumeration, knowing how to design tasks which will promote children's corrects and efficient enumeration strategies, as well as knowing how to design tasks which will assess children's counting and enumeration skills. Cell 8 refers to pedagogical-mathematics self-efficacy related to designing and evaluating tasks, such as teachers' beliefs in their ability to design enumeration tasks.

| | Subject-matter | | Pedagogical-content | |
|---|---|---|---|---|
| | Solving | Evaluating | Students | Tasks |
| Knowledge | Cell 1 | Cell 2 | Cell 3 | Cell 4 |
| Self-efficacy | Cell 5 | Cell 6 | Cell 7 | Cell 8 |

Table 1: The Cognitive Affective Mathematics Teacher Education Framework

## 3. Method

In this section we present results of studying 17 preschool teachers' knowledge of assessment tasks related to counting and enumeration. These teachers participated in one of our professional development programs which included 10 three-hour lessons spread over a period of eight months. Approximately a third of the lessons centered around number concepts, including counting and enumeration. All teachers were currently teaching children ages 4-6 years old in municipal preschools. All were licensed to teach preschool and had a B.A. degree. Before beginning these lessons, teachers were asked to fill out questionnaires, investigating their knowledge and self-efficacy beliefs. At the end of the course, teachers filled out the same questionnaire. For the final project, teachers were requested to assess the knowledge of two individual children in two different mathematical areas. The teacher was requested to video-tape herself implementing the assessment tasks with the child, write up her conclusions regarding the child's knowledge, and reflect on the process. Reflective interviews were conducted with teachers at the end of the course in order to review different elements of the program and to probe which elements were significant for that teacher.

Two self-efficacy questions related to counting and enumeration assessment tasks appeared on the questionnaire. Teachers were asked to rate, on a scale of 1-4 their agreement with the following statements:

1. I am able to build tasks which can assess children's knowledge of counting till thirty.
2. I am able to build tasks which can assess children's knowledge of enumerating 8 objects.

Following these questions, teachers were asked:

3. Which tasks would you give children to assess their knowledge of counting till 30?
4. Which tasks would you give children to assess their knowledge of enumerating eight objects?

Ample room and time was given for the teacher to write many tasks. Questionnaires were filled during the meeting with the instructor present.

## 4. Results

We begin this section by offering some general results for the group of preschool teachers who participated in this study, first their self-efficacy beliefs and then the types of tasks they presented on the questionnaires. We then focus on one teacher, Maple, and describe in detail results related to her knowledge and self-efficacy regarding enumeration assessment tasks.

A paired-samples t-test was conducted to compare self-efficacy scores before and after participating in the program. Regarding teachers' self-efficacy for building tasks with which to assess children's knowledge of the counting sequence, a significant difference was found between the pre-program ($M$= 2.71, $SD$=.85) and post-program ($M$=3.41, $SD$=.51) scores, $t(16)=-2.63$, $p<.05$, where scores ranged from 1 (very low self-efficacy) to 4 (very high self-efficacy). Likewise, regarding teachers' self-efficacy for building tasks with which to assess children's knowledge of enumeration, a significant difference was found between the pre-program ($M$= 2.82, $SD$=.64) and post-program ($M$=3.41, $SD$=.51) scores, $t(16)=-3.05$, $p<.01$. In other words, teachers' self-efficacy with regard to building counting and enumeration assessment tasks significantly increased.

With regard to teachers' knowledge of counting and enumeration tasks, we first analyzed the presented tasks to see if teachers differentiated between a task that could assess a child's knowing the counting sequence and a task that could assess children's enumeration skills. As was discussed previously, counting objects includes several skills beyond being able to recite the counting sequence. It includes the principle of one-to-one correspondence and knowing that the last number reached signifies the amount of objects in the set (the cardinality principle). It is important for a teacher to take into account the complexity of counting objects in a set and assessing the different enumeration skills. Before the program, 14 teachers presented enumeration tasks for tasks that could assess a child's knowledge of the counting sequence. In fact, two teachers specifically wrote that the same tasks using for assessing children's knowledge of the counting sequence could be used to assess children's knowledge of enumeration. After the program, five teachers still offered enumeration tasks, such as counting the number of children who came to class, when asked for tasks that could assess a child's knowledge of the counting sequence.

In addition to differentiating between counting and enumeration tasks, we also analyzed the richness and variety of tasks teachers presented. For example, knowledge of the counting sequence does not only include being able to count forward from 1 till 30 or 50. It includes being able to count forward from a number other than one, being able to count backwards, being able to count by 2s, and more. Thus, if we want to assess a child's knowledge of the counting sequence, we need to ask the child more than just to count forward from one. Counting from one is often done automatically. Before the program, all of the teachers, but one, related solely to tasks which had the children counting from one forward. None of the teachers considered asking the children to count backwards and none of the teachers considered asking the child what number comes before or after some other number. After completing the program, eight of the teachers presented a rich variety of tasks which took into consideration more than the child being able to count forward from one.

Regarding enumeration tasks, both before and after the program teachers presented tasks which included counting different types of objects. For example, one teacher said that she would set a table with eight settings and would have the children count the number of plates on the table, the number of forks, and the number of spoons.

Another teacher said that should we place on a table eight blocks and have the children count them and then she would place eight crayons on the table, and so forth. Before beginning the program, only two teachers referred to different arrangements of objects. That is, will the eight objects to be counted be placed in a pile without order or in a line or in a circle? After the program seven teachers presented tasks which included specific mention of the arrangement of the items to be counted and how the arrangements could be varied. In addition, after the program, four teachers included tasks which took into consideration assessing the child's ability of counting out eight objects from a set which contained a greater amount of items.

We now turn to the case of Maple. Maple was a teacher with seven years of experience and a B.Ed. On the pretest questionnaire she rated her self-efficacy to design enumeration assessment tasks as a 3, on a scale of 1-4 (4 being the highest score). She offered the following tasks with which to assess a child's knowledge of enumeration: "count the number of children in the group, count how many types of vegetables were brought to class, count objects which are related to the child's every-day environment." The variation in Maple's three suggested tasks is expressed in the objects to be counted. On the post-test questionnaire, her self-efficacy rating did not change. However, she now presented the following tasks: "Counting objects. Removing 8 objects from a larger group of objects. Arranging 8 bottle caps in a circle and counting them. Matching up cards that have number symbols on them to cards that have different amounts of objects drawn on them." While there was no change in Maple's self-efficacy, we do note a change in knowledge. Maple's knowledge of tasks that can be used to assess a child's enumeration skills has increased. This can be seen from the variety and richness of tasks she now presents. She specifically mentions the arrangement of items to be counted as well as the situation – pulling out 8 objects from a larger set as opposed to counting 8 items when only 8 items are present.

For her project, Maple chose to report on her assessment of a 4 1/2 year old girl in her class. Her report included her prior assessment of that girl's counting and enumeration skills, "Gila can count till 10 without making mistakes. She also recognizes the number symbols up till 5." Maple then goes on to describe seven different tasks which she chose to implement in order to assess different elements of her student's knowledge of enumeration. For each task, she wrote what specific element of enumeration skills she was assessing as well as what mistakes may possibly arise. For

example, for her first task she planned to ask the child to count till 10 without placing any items before the child. She wrote, "The first task investigates consistent and acceptable counting…if the child cannot count, and the basis for enumeration is counting, then if the child cannot count as she should, she will not be able to enumerate." For the second task, she placed eight identical objects in a row and asked the child how many there are. She wrote, "The second task investigates the one-to-one correspondence principle and when I ask again how many there are, I am checking the principle of cardinality, that the child knows that the last number represents the total amount… [It could be that] a child will count the same object twice or, instead, skip an object." Maple also planned to assess the order-irrelevance principle by asking if the objects can be counted from right to left as well as from left to right and if the amount stays the same.

After writing up her analysis of the child's performance she reflects on the process, noting not only the child's performance but her own performance as well. For example, Maple is surprised at the strategy the child used when counting 20 bottle caps placed in a pile. The child first laid out all of the caps in a row and only then proceeded to count them. This was obviously a strategy Maple had not seen previously. She also remarks in her report that when talking to the child, she, the teacher, was not consistent in her terminology and sometimes mixed up the words for counting with enumerating. Maple also notes what she would change if she were to carry out the project again. She writes, "I would emphasize the difference between counting and enumeration, before beginning to assess a child's knowledge. First I would strengthen my own knowledge and then the child's."

During the reflective interview at the end of the course, Maple was asked what she learned from the experience of video-taping her implementation of the assessment tasks and then watching the video. She noted, "It was interesting to watch myself. During class time I never see myself. It (the video) is a good tool. You can stop [the video-tape], think, watch it again, and then reflect. It really helped me to learn about myself and about the children." The interviewer also asked Maple, if she could point to some new insight that came about from her viewing the video. She answered, "First, about myself. As I conducted more assessment tasks, I saw that I was more confident in myself, more skillful with regard to conducting the assessment task. I see how I improved each time."

## 5. Summing up and looking ahead

What can we learn from our experience to promote preschool teachers knowledge and self-efficacy regarding counting and enumeration in preschool? As a group, we found that teachers' knowledge regarding counting and enumeration tasks, and the differences between them, were refined. In addition, the group as a whole significantly increased its self-efficacy regarding these mathematical domains. In other words, the participating teachers were in a better position to work with preschool children on counting and enumeration both from the content perspective as well as from the affective perspective of enacting such tasks with their students.

The case of Maple may allow us a glimpse into the process teachers underwent during the program. A specific focus on analyzing the underlying knowledge requirements of each task, as well as seeing connections between tasks, contributed to subject matter knowledge regarding tasks. Moving from the theoretical level to the practical level of implementing tasks, allowed Maple, and perhaps other teachers, to reflect not only on children's performances, but on their own performances as well. The Cognitive Affective Mathematics Teacher Education Framework, which continues to guide us in planning, implementing, and investigating the results of our professional development program, seems to have a promising potential in developing preschool teachers knowledge and self-efficacy. More research is needed, both in terms of other mathematical domains and with additional participants.

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