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Making the difference: Training early childhood math teachers in STEM skills

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ABSTRACT: *Science, technology, engineering, and mathematics (STEM) education is regarded internationally as critical to effectively preparing citizens for the twenty-first century (Early Childhood STEM Working Group, 2017; McClure et al., 2017, National Research Council, 2011). One basic assumption underlying this work is that a critical step to improve outcomes for children is to improve support for their teachers so that educators are empowered to provide high-quality STEM experiences during the first years of primary school. This paper presents the case study that emerged from the Kanga-Kids Professional Development Model of Training for in-service Math teachers in the early years of elementary school. The model includes three main components: (1) workshops, (2) reflective coaching cycles, and (3) professional learning communities/workgroups. The findings show that the program has succeeded in changing basic attitudes and beliefs as well as daily routines at school in teaching math. This paper contributes to theoretical and practical literature in the area of STEM bringing a detailed example of the design and its impact.*

KEYWORDS: **Mathematics, Teachers' development, STEM.**
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1. Introduction

Research on the issue of educating young children in mathematics has increased over the past two decades, and the long-term effects of early exposure to mathematics are now becoming clear; knowledge of math in early childhood, for example, predicts math achievement even into high school years (National Mathematics Advisory Panel, 2008; National Research Council, 2013), and preschool math skills predict later academic achievement more consistently than early reading or attention skills (Duncan et al., 2007, Hunting et al., 2012). Furthermore, some studies show math to be integral to how children learn to learn (Duncan & Magnuson, 2011). In other words, early study of math is more than simply learning discrete skills such as naming numerals; it is about reasoning and discovery. Yet many classrooms for young children focus on extremely limited objectives: for example, mastering the counting sequence, basic addition, and the names of shapes by rote consequently, these have minimal impact on children's overall mathematical proficiency (Institute of Medicine and National Research Council, 2015). Instead, educators can promote this proficiency by providing children with opportunities to reason and talk about their mathematical thinking. Early introduction to "math talk" helps children build STEM vocabularies and acquire the knowledge necessary for a deeper understanding of STEM topics later (Klibanoff et al., 2006). This case study will outline our efforts in employing evidence-based elements of effective professional development for primary school teachers in a professional development model that focuses on STEM goals using math puzzles in teaching mathematics.

Based on a theory of change, we aimed to positively influence school teachers' attitudes and beliefs, increase STEM knowledge (focused on mathematics), and improve teaching practice. Therefore, one critical step to improve outcomes for children is to help educators and empower them so that they can provide high-quality STEM experiences during the first years of primary school. Teachers deserve resources and professional support that address the possibility of negative attitudes and beliefs about STEM to increase their knowledge and, ultimately, to improve their teaching abilities. Thus the teachers can confidently and successfully incorporate rich STEM experiences in their classrooms and successfully guide the different students in their classrooms. We hope that our model can serve as an example to other researchers and practitioners interested in teacher education and professional development around childhood STEM issues and in supporting diverse learners in all settings.

This paper is the product of the collaboration between the In-Service Program Designer, and the In-Service Program Evaluator. All the data presented here is part of the evaluation report requested by Beer- Sheva Municipality Ecosystem who initiated and supported the project.

2. Background

STEM is an interdisciplinary approach to learning where content is coupled with real-world lessons as students apply science, technology, engineering, and mathematics in a context that makes connections between various aspects of their lives (Lantz, 2009). The quality of children's learning environments influences later academic success (Campbell et al., 2001; Hadzigeorgiou, 2002). Thus, appropriate STEM experiences in early childhood can be starting points for supporting children's continued successes in STEM at elementary, secondary, and postsecondary levels. Furthermore, the National Science Teachers Association (2014) suggests that early childhood education may offer opportunities for teachers to engage in science and engineering activities that capitalize on students' interests, experiences, and prior knowledge in natural extensions of purposeful play.

Various goals of STEM education for student development have been proposed, including students' knowledge of the fundamental concepts relevant to STEM, their understanding of the characteristic features of STEM disciplines, their acquisition of skills addressing the STEM-related questions and problems, capabilities relevant to the 21st century (such as creativity, critical thinking, communication, and collaboration), and positive attitudes (such as interest, engagement, and self-efficacy) toward STEM (Bybee, 2013; National Research Council, 2014). Until now, a great deal of research has been conducted on the positive impacts of STEM education at school levels, such as effect on the academic achievements of high school students and their career choices (Han, 2017; Han et al., 2015), and elementary and middle school students' dispositions toward STEM (Afriana et al., 2016; Christensen et al., 2015; Guzey et al., 2016).

The necessity of early exposure to STEM was highlighted by several scholars (Bagiati et al., 2010; Bybee & Fuchs, 2006). It was argued that young children are congenitally curious, creative, and collaborative, which are the same attributes needed for STEM education, and these attributes in young children have made them naturally interested in STEM-related concepts (Banko et al., 2013; Reis & Renzulli, 2009). Furthermore, children have innate intellectual tendencies that enable them to learn STEM, such as the ability to make sense of experience, to analyze, hypothesize, and predict (Katz, 2010).

Early childhood science instruction should address what children know and what they can learn and should include an inquiry approach, and provide the appropriate platform to promote conceptual understanding and reasoning (Leuchter et al., 2014; Roth et al., 2013). Eshach and Fried (2005) argued that science is an important—and perhaps imperative—component of early childhood education because it builds upon students' innate interests in the natural world, can help develop positive attitudes towards the discipline, and can provide a foundation upon which further learning and understanding can be built.

However, research suggests that current professional development systems are ineffective and make little or no impact on teacher behavior or child outcomes (Farkas et al., 2003; Joyce & Showers, 2002; Snyder et al., 2011). Traditional methods of professional development such as training sessions, workshops, and conferences have been found to increase teachers' awareness; however, these forms of professional development are not associated with teachers' sustained use of research-based interventions (Artman-Meeker & Hemmeter, 2013; Odom, 2009). Alternative research-based professional development is critical. Assessments demonstrated that the provision of high-quality professional development has shown significant improvement in young children's achievement (Brendefur et al., 2013; Kermani & Aldemir, 2015). Professional development should be ongoing and appropriate to the subject matter being taught, it should include opportunities for teachers to actively participate and have some relevance to what is happening in the classroom (Garet et al., 2001).

However, many early childhood teachers are neither eager nor prepared to engage children in rich experiences in domains other than language literacy (Duschl et al., 2007, Clements & Sarama, 2014, Brenneman et al., 2009). In fact, widespread anxiety about topics such as mathematics exists among teachers of young children and correlates with their students' achievements (Beilock et al., 2010). Furthermore, many teachers do not know how to adapt STEM instruction to suit the needs of their students.

Many teachers continue to hold negative feelings about math and science even after graduation. In mathematics, for example, these feelings lead to undervaluing the teaching of math, avoiding or minimizing math instruction, and ineffective ways of teaching the subject (Huinker & Madison, 1997, Lee & Ginsburg, 2007). Similar trends appear in science education. Consequently, we need to effectively increase teachers' STEM knowledge and change negative dispositions and beliefs through high-quality pre- and in - service professional development.

3. STEM Theoretical Framework

According to Murphy et al., (2018) the STEM theoretical framework consists of six elements of effective education: capabilities, dispositions, educational practices, equity, trajectories, and educator capacities.

3.1. Capabilities

STEM capabilities "include, but are more extensive than, the knowledge and skills associated with the individual STEM disciplines" (Murphy et al., 2018, p. 3). STEM knowledge should be seen as flexible and evolving, rather than conceived as stable content. STEM skills are similarly flexible and diverse, and include skills such as adaptability, problem-solving, creativity, critical thinking, and design thinking (Bybee 2013; Prinsley & Baranyai, 2015). Literature suggests that STEM capabilities are best developed through STEM education practices that use real-world contexts and present learners with authentic problems or projects to work upon (Hefty, 2015; Kelley et al., 2010).

3.2. Dispositions

STEM dispositions are "the attitudes and states of mind that support students achieving success in STEM education and the pursuit of STEM career pathways" (Murphy et al. 2018, p. 3). Research literature highlights the role of enthusiasm in effective STEM education and advocates for favorable dispositions toward STEM skills to be cultivated from the early childhood years onwards (Patrick et al., 2009). Children's STEM dispositions can be influenced by educators, and teacher practice, curriculum, and pedagogical choices can have a significant impact on children's dispositions (McPhan et al., 2008).

3.3. Educational Practices

STEM educational practices are "intentional actions that schools and educators take to create STEM learning environments that build student STEM capabilities and nurture STEM dispositions" (Murphy et al. 2018, p. 4). There is general agreement that real world inquiry and problem-based learning have a positive impact upon students' STEM capabilities and dispositions (Gee & Wong, 2012; McDonald, 2016). There is also a call for the increased use of digital technologies in STEM education on the basis that digital learning practices broaden available learning contexts (Starkey, 2012), facilitate the development of problem-solving and higher order thinking skills (McDonald, 2016), and improve student interest and motivation in STEM (McDonald, 2016; Starkey, 2012; Toh et al., 2016).

3.4. Equity

Research has established that there are a number of inequities in STEM achievement, particularly for female, rural, indigenous, and socio-economically disadvantaged students (Murphy et al., 2018). Effective STEM education must seek to address these inequities through curricular and pedagogical choices that have a positive impact on the dispositions and academic success of different groups of learners (Gee & Wong, 2012; Patrick et al., 2008).

3.5. Trajectories

A student's STEM trajectory is a long-term view of his or her movement through the education system, from early childhood through to senior secondary years and beyond (Murphy et al., 2018). International research demonstrates the relationship between early STEM capabilities and later outcomes in STEM (Johnston, 2011; Watts et al., 2014).

3.6. Educator Capacities

Effective STEM education requires educators who are able to deliver inquiry-based STEM programs that develop STEM capabilities and positive dispositions for all children (Murphy et al., 2018). Research shows that STEM professional development can deepen both the content and pedagogical knowledge of educators, leading to positive changes in classroom practice and improved student achievement (McDonald, 2016; Reimers et al., 2015).

The *Kanga Kids* program is based on professional development workshops for childhood educators who then facilitate the program in their classes.

We used the following teaching-learning cycle of mathematical investigation suggested by Applebaum and Samovol (2002) to construct a learning activity.

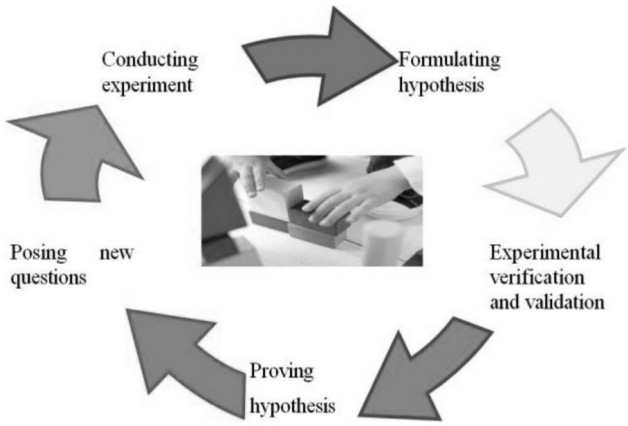

Figure1: Teaching – learning cycle of math investigation

In this schema, we see how in-service teachers (and then their students) gradually become engaged in mathematical exploration: posing questions, conducting experiments, formulating hypotheses, verifying, and validating, proving, and formulating new questions for further exploration, thus launching a new learning cycle.

Research Questions

Research question 1. What activities does the program include and how do they meet the program goals? How are those activities characterized?

Research question 2. How, and to what extent, has the program succeeded in changing teachers' attitudes toward mathematics?

Research question 3. How, and to what extent, has the program succeeded in changing teachers' routines in the classroom during math lessons?

4. Program Description

The in-service training course was designed for first- and second- grade math teachers. Fifteen teachers chose to attend the course. All participants were certified teachers, of whom eleven with Bachelor's degrees and four with Master's degrees; all were aged between 35 and 50. They all teach at elementary schools (1st to 6th grade). It is important to stress that each classroom comprised 32-35 students in extremely heterogeneous groups from a socio-economic point of view.

Eight four-hour workshops over one semester aimed at delivering modules that focus on mathematics concepts and different strategies of problem-solving. During each workshop, teachers were given an overview of the research and best practices relating to that topic, as well as relevant content knowledge and concrete implementation strategies. According to the reflective coaching cycle protocol (Costa & Garmston, 2002; Riley-Ayers & Frede, 2009), all participating teachers implemented a math lesson based on one of the model lessons provided and practiced during the workshop. The coach aided teachers in planning this lesson. After its completion, teacher and coach each completed a brief reflective evaluation of the lesson. The team then reflected on what went well and what could be improved, taking pointers from the lesson just given, and teacher and coach set objectives for improvement based on the teacher's completed self-evaluation. The course took place in 2020 during the COVID-19 pandemic. Therefore, all meetings were conducted through the Zoom videoconferencing platform from participants' homes. During the second semester the coach meets teachers for one-to-one, hour-long meetings every four to six weeks focusing on a teaching or learning issue and feedback.

The Kanga-Kids program utilized summaries by Brenneman (Brenneman et al., 2019) and adopted and implemented the ten best practices of professional development that support the program: (1) to include educators and administrators in the ongoing design; (2) to include professional supports; (3) to boost teachers' content knowledge; (4) to take into consideration teachers' attitudes and beliefs; (5) to engage with teachers on different levels (large and small groups, one-to-one); (6) to connect the material with relevant classroom practice; (7) to involve educators in feedback and reflective coaching cycles; (8) to establish a collaborative learning community; (9) to ensure that the program is ongoing and long term; (10) to ensure that the material is individualized to suit the needs of the particular classroom.

The Kanga-Kids professional development model accomplishes this through three main components: (1) workshops providing mathematics content and pedagogy to teachers, thus supplementing their knowledge of the subject at hand and development of new teaching strategies; (2) reflective coaching cycles providing individualized coaching, goal-setting, and feedback; (3) professional learning communities/workgroups, bringing small groups of teachers together for coaching and to discuss mutual professional problems.

5. Methodology

This case study within the paradigm of qualitative research utilizes an approach close to anthropologist methodology (Scriven, 1991). The case study was based on observations during the study meetings and interviews with the participants four months after the meetings ended, and the analysis of educational products composed by the participants. In this case, there has been significant focus on the thick description of the process, the raw materials and the collected data (Geertz, 1990) of the intervention (Mertens, 2020) during the in-service training course (ISTC). All the meetings were video recorded. The recordings, that were the result of working online during 2020 when COVID-19 made physical meetings impossible, enabled the evaluator to observe the meetings repeatedly and find more new data. The data was first analyzed based on grounded theory (Glaser & Strauss, 2008). The findings were then compared to other theoretical models such as Reis and Renzulli's model of excellence (2009) and Murphy's conceptual framework (2018).

6. Findings

The findings answer the research questions through their description and the conceptualization of the ongoing collaborative training that took place during the meetings, thereby showing the changes in teachers' attitudes and in their teaching routines.

6.1 The ongoing collaborative training

Meetings took place in a pleasant atmosphere with time for organizing thoughts and getting comfortable. Adam (the lecturer and coach) usually invited the participants to take part in entertaining exercises. For example, during the second meeting, he said: *"Last week, we talked about "creativity". I noticed that the date was 11.11.20. Nice date. So, I thought to ask a mathematical question about the date. I want to ask you to add an equals sign between 11, 11, 20, 20 and to add an operation, thus forming an equation."*

The participants were silent and worked by themselves. They could be seen in their frames on screen.

Adam: *"We can place numbers side by side. This may be too much for little children. Older kids can add multiplication and division signs. In first and second grades it's enough to work with plus and minus. Let's try. You are not in the first grade. You can go wild. Please write your suggestions on the chat."*

By starting the meeting with math games, Adam unveiled the practical meaning of creativity. Through his amusing way of teaching, he became a model for implementation and allowed the participants to experience mathematics as entertainment. Later, in their work in the school environment, it will be seen how the idea is translated at the first- and second-grade levels.

Adam: "*I'll start with the simplest example: 11-11=20-20"*

Participant A: *"2+0+2+0=1+1+1+1"*

Adam: *"This exercise is suitable for the first grade too."*

Participant B: *"Middle first grade."*

Participant C: *"It fits the end of the first year better."*

Participant D suggests another exercise: *"2+0+2x0=1x1+1x1"*

This kind of 'activity' is not included in exercises in the school curriculum repertoire. The participants played a double role in this activity: as students, searching for interesting suggestions and answers, and as teachers, evaluating their own suggestions and those of the other participants as suitable or unsuitable for their pupils. The setting also enabled them to share pedagogical content knowledge as described by Shulman (1986).

Adam then asked: *"Why is it good to bring children together with this kind of work? We want to start exposing children to the possibility of more than one solution from an early age. But in school, we ask them for the one right solution. Most of the exercises in the curriculum lead to only one correct answer. We can show children that there may be many solutions… we can ask them to compose their own exercises and then suggest that their classmates find the solutions…"*

Adam asked the participants to implement in their classrooms the principles presented in the course. He suggested that this is the kind of class activity to develop mathematical thinking from the early stages of the educational system.

During the meeting, Adam went deeper and brought up new activities. According to Reis and Renzulli (2009), giftedness will be achieved by above average ability, creativity, and task commitment – creativity meaning fluency, flexibility, originality of thought, openness to experience, sensitivity to stimulations and willingness to take risks.

The meeting ended with a short lecture about creativity. Adam mentioned mainly originality, fluency, and flexibility, and ended by saying, *"not only in math but in every content you teach."*

Adam exposed the participants to the idea of developing mathematical thinking from an early age. He expanded on the idea through personal experience and activities. By "playing" with math he exposed the teachers to an enjoyable setting which became a model for the classroom experience. He asked to copy the method in the school environment conceptualized the process, thus bringing theoretical knowledge on creativity to broaden participants' pedagogical content knowledge.

6.2. Changes in participants' attitudes after the in-service training

We learned from interviews with the participants that some basic attitudes had changed. For example, Participant A, a young teacher, stated: *"I don't like numbers and I don't like math. But I do have to teach it… here I learned that all children are able to learn math. This course is suitable for teachers like me".*

Participant B, a well-known math teacher with many years' experience commented: *"I thought I would start the developing of mathematical thinking with a small group of four children* *whom I had evaluated as very good pupils. Suddenly, they didn't know everything, and they had to think. This course sharpened [my vision] very much. I understood that children can deal with the challenge. I learned I must challenge them all without looking at their grades."*

Participant C said: *"Children discover a new type of math from an experiential point of view. It was good also for me as a person [to look in this new way at math]."*

These opinions show that the changing attitudes didn't depend on experience nor on a basic positive attitude for math. Evidently, the course affected each of the teachers differently, but highlighting two main points: a more positive attitude toward math, seeing it as fun or a game, and the realization that mathematical thinking is not appropriate for a select group of pupils, but for the whole class.

6.3. Changes in participants' teaching routines after the in-service training

From the interviews with the participants and their presentations in class, we were able to learn about changes they made in their teaching routines. Participant A explained that: *"After a few meetings, I began using all the new ideas in class. I presented the riddles to my pupils at the beginning of the lesson. It became a real game. I implemented all the ideas!".*

According to Participant B: *"I used all the accessories, the colored threads… a wonderful program! Especially for young kids! This is an experimental and experiential way of learning!"*

Another participant stated: *"…the lesson lasted for half an hour. The kids participated and wanted to show their solutions to the problem. I enjoy math lessons. I like to listen to the children all explaining their means to their answers."*

All participants reported some kind of change in their routines in math lessons. Changing basic attitudes and routines in the classroom is evidence of the effectiveness of the course.

As previously mentioned, all the participants in the in-service teacher's course presented one event from their classroom that new ideas were implemented. The following is one example showing the extent to which the course influenced teachers' work in class.

Helen, a teacher of first-grade students, described implementation of what she had learned during the in-service course:

The subject of the lesson: Mathematical Thinking Development using Kangaroo Contest Puzzles.

Goals: Students will practice addition till 20; students will practice solving chain exercises; students will solve the problem using teaching aids; students will know different ways of solving problems.

Participants: all children present in the classroom.

Accessories: Projector for projecting puzzle, sheet for painting - "My Yard", pictures of cats, dogs and chickens.

Steps:

Students painted their yards (on a given sheet).

Figure 2:The sheets painted by students

Each student received 4 pictures of cats, 4 pictures of dogs and 10 pictures of chickens, and all were asked to place some of the illustrations on their sheets and to answer the following questions:

Place two pictures of the same animal. How many legs are there in your yard?

Place two pictures of different animals. How many legs are there in your yard?

Place animal pictures in a way that there will be an even number of animal legs. Present the various options.

Is it possible to place an odd number of legs?

After the students had discussed the above questions, the next problem was projected on the board:

Granny went out to the yard and called all the hens and her cat. All 20 legs ran to her. How many hens does granny have?

Figure 3: Hens and cat
(A)11 (B) 9 (C) 8 (D) 6 (E) 4

Helen's comments (HC): Each time a student suggested a solution we tested it using animal pictures on the board and by counting.

S1 (Student 1): 6 chickens. Because I counted them in the picture (the illustration of the task projected on the board) and there are 6 chickens.

HC: To check his answer I asked all students to place 6 chickens and one cat on his sheet and to check if there were 20 legs in total. Students found that the number of legs was not 20.

SK2: 20 chickens because we were given 20 in the task.

S3 rejected this answer and explained that there were 20 legs and therefore there could not be 20 chickens because each one has 2 legs.

S4: 10 chickens and in total we have 20 legs and 4 cat's legs.

HC: During the explanation, S4 realized that he was wrong and said: "I got mixed up."

S5: 9 chickens. I did the exercise and got 20 legs.

HC: To check the solution, students place 9 chickens and one cat on their sheets and found that the number of legs was more than 20.

S6: 11 chickens. First, let's count 4 legs of a cat and then I added legs of 11 chickens.

HC: Using pictures and counting the legs, the children found that the number of legs was more than 20.

HC: I suggested using S6's strategy and to start counting with the cat's legs.

S7: 8 chickens. After I put the cat on the sheet, I added chickens one after the other and counted their legs until I reached 20, and then I counted the number of chickens I had added.

HC: All students checked S7's solution and wrote down:

4+2+2+2+2+2+2+2+2=20

Like Adam, Helen invited her pupils to "play with math". She is implementing the kind of creativity she was exposed to during the in-service training course. Indeed, it seems that Adam succeeded in becoming a role model for the participants which is clearly seen in Helen's implementation of his program. As mentioned above, the ideas were implemented to suit the first- and second-grade levels.

The idea of looking for several possible solutions to a math problem is certainly not included in the formal curriculum for first and second grades, nor does it appear in the textbooks children deal with at school. Helen enabled the children to "talk math" and think together in collaborative ways, thus leading them towards mathematical thinking.

6.4. Teacher's Reflection

"I really enjoyed seeing the children testing their solutions using their sheets and pictures of animals. The children also enjoyed solving the problems and were very active."

Like Adam, Helen exhibited educational practices that build a STEM learning environment: she conducted problem-based learning while encouraging students to be active and enjoy the learning process.

"It was important to them to share with me their solutions to solve all the questions posed. When they saw that I had photographed some of their solutions it seemed that they were even more motivated to present new solutions and asked me to photograph their new solutions."

"I found the problem they solved was difficult for almost all of them. I saw them debating whether to place the pictures on their sheets, removing others, unsure of their answers. The idea to start with the cat's legs and then to add chickens one by one (S6), was brilliant and it really helped the other students to reach the solution."

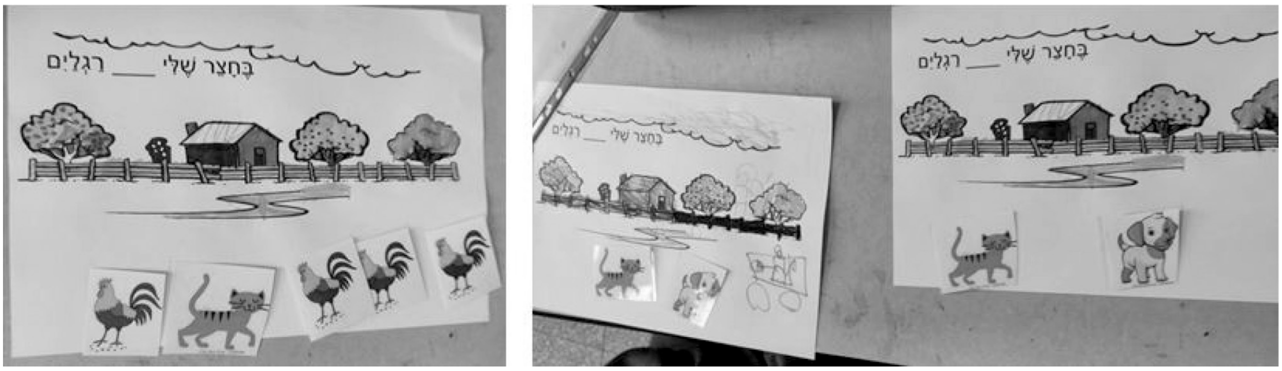

Figure 4: Second grade students' worksheets

I also realized that if a non-standard problem is used in a lesson, it is not possible to plan the whole lesson in advance, because the children's answers and insights are unpredictable.

Once a child suggests a wrong solution and justifies his answer, a way must be found to explain where he went wrong, to draw conclusions and present new ideas."

Helen made it possible for her students to share their solutions. Photographing their work transmits her appreciation for their work and her desire to document and preserve their outcomes, thus motivating them to participate in the activity.

She is aware of the challenge posed to the students and appreciates their debates and efforts. She is flexible and understands she cannot predict the whole lesson because fluidity is needed to conduct such an unpredictable conversation among the children.

It is important to stress that during the interview, Helen explained that when she started the in-service course, she didn't believe in her ability to implement the new ideas with all her class. At the beginning of the first term, she experimented with the four children she evaluated as her best pupils. Only during the course did she arrived at the understanding that this kind of work can [and should][1] be done with all children. In her own words: *"When you work with illustrations it interests all the children"*. She understands that their participation depends on the way the lesson is presented and conducted.

1 Researchers' addition.

7. Discussion and Conclusions

Professional development should include methods for modeling and fostering creativity in the classroom. Many educators struggle to understand that creativity development is fostered through a process of exploration, play, risk-taking, making mistakes, self-evaluation and feedback (Runco, 2014; Sternberg & Williams, 1996). All these principles were successfully implemented in the Kanga-Kids in-service teachers training course.

In line with Murphy et al. (2018), based on the implementation of the model and the evaluation research findings, it can be said that Kanga-Kids met its main goals. The program provided high-quality STEM professional support while simultaneously being practical to implement, enjoyable, and useful to educators and their practice. This paper was written to exemplify how a professional development model that is research-based, collaborative, and realistic when put into practice in settings serving diverse learners can be designed. As can be seen from the findings, the program unveiled creative ways to teach math using puzzles. The instructor influenced teachers' basic dispositions through openness to experience and pedagogical choices that had a significant impact on the educators' ways of thinking. It was shown that leading *"intentional actions…. to create STEM learning environments, build STEM capabilities and nurture STEM dispositions"* (Murphy et al., 2018, p.4). Teacher professional development focusing on high-quality math education can support educators in creating effective childhood education programs for all children.

The participants and instructor were extremely satisfied with the resulting model and reported that all three main components (workshops, reflective coaching cycles and feedback, and professional learning communities/workgroups) were enjoyable and beneficial for their practice.

The educators evaluated the implementation of the Kanga-Kids program as positive for creating a community of inquiry where children and educators study and research together, with space for children's self-directed and discussion-based explorations. Adults can take on varied roles, including director, helper, or partner to children's learning. Educators' confidence in teaching STEM increased, and participants reflected on their opinions and attitudes, and implemented their newfound knowledge in class. Through Kanga-Kids, they were able to overcome doubts and have realized that STEM can be simple and is present in everyday activities.

In conclusion, it appears that participation in Kanga-Kids has offered a variety of benefits to participants and subsequently, the children benefit as well. Five (out of the six) elements of effective STEM education as outlined by Murphy et al. (2018) were evident among the corpus of qualitative data from the evaluation study: capabilities (creativity, problem-solving, design thinking), dispositions (the effect of a pleasant teaching/learning atmosphere and pedagogical choices), educational practices (in terms of problem-solving and higher-order thinking skills), equity (in terms of novices and experienced teachers), educator capacities (the instructor exhibited the ability to deliver inquiry-based STEM meetings).

Our study also provides evidence that STEM education should be implemented during early childhood since the majority of the in-service teachers in the present study stated that STEM education is suitable for early childhood education. Following up on their own experience as learners and then as teachers, all in-service teachers also expressed their commitment to developing STEM skills in early childhood education.

We believe that the present study contributes to the current literature related to STEM education in early childhood, particularly in its presentation of a good example of professional development for in-service early childhood teachers in the context of integrated STEM education. Finally, the results obtained from the current study may be beneficial in providing implications for early childhood education program developers, as well as their offering an example of STEM instruction content and processes for early childhood educators and researchers.

In addition, ongoing research is necessary for testing the effectiveness of the model anticipating changes in teachers' attitudes, opinions, and teaching practices and for improving education for students throughout the educational system.

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