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Perceptions of mathematical creativity among math teachers in special education classrooms

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Encouraging mathematical creativity is one of the aims of mathematics education. The present study examined teachers' perceptions of encouraging mathematical creativity in special education classrooms (SEC). Three teachers of mathematics in SEC were interviewed regarding their perceptions of mathematical creativity and their role in encouraging mathematical creativity in SEC. Findings indicated that the teachers believe in the importance of fostering mathematical creativity among their students. In general, they indicated that their role was to create a supportive environment that encouraged students to think on their own. Professional development is needed specifically to introduce teachers to tasks that can promote mathematical creativity.

Keywords: Mathematical creativity, teachers' perceptions, special educational needs.

Introduction

Encouraging mathematical creativity is an important objective of mathematics education (Levenson, 2013). Research suggests that promoting mathematical creativity can strengthen the connections between different topics both within and outside of mathematics, and extend prior knowledge (Leikin, 2009). Alongside increased awareness of classroom mathematical creativity, there is growing awareness of the importance of offering equal learning opportunities for all students (DeSimone & Parmar, 2006). Teaching that exposes students with special education needs (SEN) to a range of strategies can encourage flexibility and creativity, along with a deeper understanding of mathematics, leading to improved accuracy and foster performance among students with SEN (Peters et al., 2014).

The teacher has a significant role in fostering mathematical creativity in both, general and special education classrooms (SEC). Previous studies have shown that mathematics teachers' beliefs and perceptions can affect their teaching methods as well as decisions made in the classroom (Schoenfeld, 2011). Likewise, beliefs teachers hold about creativity can influence what they do in class. Some mathematics teachers regard creativity as an acquired skill which students can develop (Lev Zamir & Leikin, 2012), while others believe that only some students have the ability for creativity (Shirki & Lavy, 2012). The current study examines the perceptions of three mathematics teachers who teach in SEC within general education schools, regarding encouraging mathematical creativity among students with SEN. SEC have a small number of students, where each student learns according to an individual learning plan, and yet may be mainstreamed in certain subjects according to ability.

Theoretical background

Our theoretical perspective of mathematical creativity is in line with Silver (1997), who viewed mathematical creativity as "an orientation or disposition toward mathematical activity that can be fostered broadly in the general school population" (p. 75). Mathematical creativity is commonly assessed according to three criteria: *fluency***,** the number of distinct solutions, possibilities, or ways of solving a given problem (Leikin & Lev, 2013); *flexibility***,** breaking away from familiar and fixed

patterns, posing ideas from different fields of mathematics, examining a problem from different angles, expressing solutions by means of different representations (Leikin, 2009; Levenson, 2013); and *originality***,** finding a new or unusual way to interpret an idea or solution (Silver, 1997).

Promoting mathematical creativity in the classroom is the teacher's responsibility, beginning with choosing appropriate tasks. Many researchers recommend engaging students with open tasks that have many answers (e.g., Levenson, 2013). Leiken (2009) recommends engaging students with multiple-solution tasks that have one final answer but many ways to teach that answer. Another type of task is problem posing, often associated with promoting flexibility (Silver, 1997). Another responsibility of the teacher is creating an environment where mathematical creativity can thrive. For example, when a teacher relinquishes some authority as the primary source of knowledge, that teacher creates fertile ground for experimentation and investigation, encouraging students to pose questions and draw conclusions. By creating a climate that makes the classroom a safe environment for posing new and original ideas, and navigating the mathematical discourse, the teacher can encourage the development of mathematical creativity among students (Levenson, 2013).

Previous studies investigated teachers' perceptions of creativity in general education classrooms. For example, elementary mathematics teachers in general education were found to perceive mathematics as a subject with limited opportunities for creativity (Bolden et al., 2010). Although they believed that creativity is important in general, they regarded mathematics as a subject characterized more by logic than by creativity, unlike subjects such as art, music, and language (Panaoura & Panaoura, 2014). Thus, in practice, they failed to create a climate that fostered mathematical creativity in the classroom. Bolden et al. (2010) indicated that teachers believe mathematical creativity manifests itself in teaching that utilizes a range of resources (e.g., technology) and examples from daily life. Other studies found that some mathematics teachers associate mathematical creativity with tasks that are different or unusual, and tasks that have multiple answers (Levenson, 2013). At times, although teachers choose appropriate tasks that have the potential to occasion mathematical creativity in the classroom, there is a gap between the potential of the chosen task, and the way it is implemented in the classroom (Lev-Zamir & Leikin, 2013).

In contrast to the abundance of studies on teachers' perceptions of mathematical creativity in general education, few studies have investigated the encouragement of mathematical creativity among students with SEN. However, studies have examined teachers' views on teaching mathematics for these students, revealing a dispute regarding appropriate teaching methods. Some argue that for students with SEN, mathematics education should focus only on a handful of problem-solving strategies and on achieving an optimal level of proficiency in just a few calculation procedures (Geary, 2003). Others maintain that teaching procedural knowledge based on memorization and retrieving facts is difficult for some students with SEN, and therefore, those students should be exposed to a variety of strategies and encouraged to develop flexibility and creativity (Peters et al., 2014). Creating learning opportunities that encourage students to tackle mathematical challenges and find different ways to solve problems can help even cognitively less proficient students develop mathematical competence (Jonsson et al., 2014). Regarding the issue of equal opportunities in mathematics classrooms, some educators argue that just exposing students with SEN to the same content and topics as those in general classes is insufficient, and that it is necessary to provide teachers

with appropriate training and support, so that they can make adjustments for their students by, for example, extending the time of learning and practice (DeSimone & Parmar, 2006).

The purpose of this study was to examine the perceptions of teachers who teach mathematics in SEC within general schools, towards promoting mathematical creativity among students with SEN. The research questions are: How do teachers of students with SEN perceive mathematical creativity? How do teachers of students with SEN perceive their role in encouraging mathematical creativity in a special education classroom?

Methodology

The study included three teachers from three different schools in Israel, who teach mathematics in SEC within general mainstream schools. As can be seen in Table 1, their training background and teaching experience were quite different, representing the reality in Israel. Some teacher colleges offer additional mathematical content training for prospective special education teachers. Ravit had such training, while Irit did not. Rachel had no formal training to teach students with SEN, but instead had a stronger mathematical content and mathematical pedagogical knowledge than Ravit and Irit.

Table 1: Background of the research participants

Teacher	Pre-service education	Years of experience teaching …			
		School, students	Mathematics (non SEC)	Special education (not math)	Mathematics in a SEC
Ravit	Special education + mathematics	Primary students with learning disorders	–	12 years	4 years
Irit	Special education	Primary students with autism spectrum disorder	–	–	12 years
Rachel	Computer science + mathematics	Middle school students with learning disorders	19 years	–	6 years

The study was conducted using a semi-structured interview. The main interview questions were: (1) Is mathematics a creative discipline? (2) Should mathematical creativity be encouraged in SEC? Why? (3) How can mathematical creativity be encouraged among students with SEN? (4) Can tasks that has been shown to encourage mathematical creativity be used for teaching mathematics to students with SEN? (5) Do you implement such tasks in your classroom and if so, how?

Each interview with the researcher lasted between 25 and 45 minutes. The teachers were asked to answer the questions based on their teaching experience, both in mathematics and in special education. For interview question (4), teachers were presented two multiple-solution tasks, a type of task that has been shown to encourage mathematical creativity (Leikin, 2009; Silver, 1997). For example, the first task showed a diagram of 25 circles organized in the form of a diamond, where the

learner is required to identify how many circles are in the diagram and then find as many ways as possible to count them. The interviews, which were conducted via Zoom in the afternoon hours after the end of the school day, were recorded and transcribed by the researcher.

Findings and Discussion

Inductive analysis of the data led to three main themes: what is mathematical creativity; the teacher's role in encouraging mathematical creativity; and tasks that occasion mathematical creativity.

Mathematical creativity from the perspective of teachers who teach mathematics in SEC

To the question, "Is mathematics a creative discipline?" only Rachel responded in the affirmative, although she found it difficult to explain why. The other two teachers did not respond at all. Instead, Irit and Ravit, and later also Rachel, responded by relating how they themselves teach mathematics. For example, Irit defined mathematical creativity in the following way: "Creativity (pause) [means] bringing something different, illustrating [the mathematics] in a concrete way, and making it come alive." For Irit and the other teachers, mathematical creativity had more to do with the way they teach, than the way the students learn. Specifically, they all mentioned the use of manipulatives, as related to mathematical creativity. This finding is consistent with Bolden et al.'s (2010) study of general elementary school teachers' who believed that using a variety of methods and examples from daily life is an expression of mathematical creativity.

To understand why the teachers in this current study associated mathematical creativity with the use of manipulatives, we consider their pedagogical knowledge in the realm of special education. Students with SEN often struggle to draw connections based on previously acquired knowledge, and need mediation and curriculum adjustments in order to properly establish new knowledge (Hunt et al., 2016). In the interviews, the teachers frequently expressed those students with SEN need a lot of "manipulatives," "visualization", and "repetitiveness". The teachers' reference to manipulatives may have stemmed from their need and desire to make the mathematical content more interesting, or from wanting to illustrate the content in a way that students would be able to understand. For example, Irit stated: "[Mathematics] can be either very dull or [by using concrete manipulatives] very interesting". Rachel, who was not trained as a special education teacher, illustrates the second viewpoint: "Their (students with SEN) ability to read (understanding underlying meanings), to teach them mathematics … one has to understand that the pace is different … to encourage them to learn in a different way."

Nevertheless, when the researcher delved deeper and the teachers were asked directly whether students with SEN ever exhibit mathematical creativity, they did refer to flexibility and originality, although not necessarily using those terms. For example, Rachel related to flexibility and originality thus: "Some students solve questions in such a creative way that I'm simply stunned … in motion problems, [they] don't use the familiar formula (velocity × time = distance); they solve it in an entirely different way." Rachel is hinting at original thinking. She added, "creative students are students with a different, not rigid way of thinking". This refers to flexible thinking. Rachel also referred to unique representations of solutions, which is another characteristic of flexibility (Leikin & Lev, 2013). She said: "In geometry there is room for creativity … using building blocks, folded paper. We do a lot of creating." Ravit also related to flexibility, in the sense of breaking away from a familiar and fixed pattern and combining ideas from different fields (Levenson, 2013). She attempted to define what

creativity is, saying: “using what was learned in one mathematics topic, when solving a problem in another mathematics topic.”

Interestingly, the teachers also believed that creativity in mathematics can emerge through students’ mistakes. For example, Irit said: “Even if someone (a student) says something that is incorrect but explains his reasoning and says why he thinks it’s right, in my opinion it’s even more creative.” Rachel also referred to learning from mistakes as part of the process of mathematical creativity: “If a student does something and makes a mistake, I allow these mistakes. I let them express mistakes. I think mistakes are part of the learning process, and I give a lot of credit (in the positive sense) to mistakes.” Analysing these comments from the standpoint of mathematical creativity shows that the teachers create a safe environment for their students and encourage them to raise new and original ideas (Levenson, 2013), without fear of failing.

Throughout the interview, teachers also referred to difficulties in teaching mathematics to their students. For example, Ravit said that “the students are largely set in their patterns”. The phrase “set in their patterns” was used by the two other teachers as well, hinting that the teachers believe it is difficult for their students to adopt a variety of methods for solving problems. This is in contrast to educators’ suggestions of having students solve problems using different strategies and methods, promoting fluency and flexibility (Levenson, 2013).

The teacher’s role in encouraging mathematical creativity

When the three teachers were asked if and how mathematical creativity can be encouraged in their classes, all three teachers mentioned the types of questions they ask during mathematics lessons. For example, Irit said that she asks: “How did you reach this [solution]? What did you do and how did you know to do it that way?” Ravit asked more general questions which by their generality may be said to encourage fluency and flexibility: “I ask them, ‘How can this be solved? In which ways can this be solved?’” This type of discourse encourages students to think of more than one solution method, which promotes mathematical creativity, and assists in constructing knowledge. By asking open and guiding questions, the teacher raises the level of thinking, opens new channels of thought for the students, and encourages mathematical creativity. On the other hand, none of the teachers stated that they ask individual students to solve a problem in more than one way (Levenson, 2013).

Teachers also mentioned their role as mediators in the learning process, which they believe leads to the encouragement of mathematical creativity. Rachel described what happens in class after she gives students a task to work on individually: “First of all, the student thinks, he constructs some knowledge. I give him the feeling that he’s not alone. I guide him. It’s a learning process.” Rachel continued to describe how the lesson develops and how different students describe different solutions to their classmates: “The students explain … sometimes their classmates manage to understand it better [than the teacher’s explanation].” It appears that the teachers believe that mediation and working together with the students, is an important aspect of promoting expressions of mathematical creativity, as well as constructing the subject matter.

Teachers also believed that their role is to motivate students and that mathematical creativity can be a means to increase motivation. Phrases such as “fear”, “passiveness”, “(low) self-confidence”, “challenge”, “emotional aspect” were very common among the teachers’ description of the climate

in mathematics classes. Rachel suggested that the added value of encouraging mathematical creativity is a way to boost motivation: "You give students the feeling that they are doing it on their own … a sensation of learning. Rather than acquiring and 'regurgitating' the material … [that way] they explain how they arrived at the solution …". This is in line with Peters et al. (2014) who suggested that encouraging mathematical creativity creates a challenge for the students and thus students are more active and involved.

As seen above, the teachers appreciate their roles in encouraging mathematical creativity in special education classrooms. They encourage students to solve problems in different ways and avoid dictating only one correct right way, thereby allowing expressions of flexibility and originality.

Incorporating tasks that occasion mathematical creativity among students with SEN

Unlike when teachers were asked about their roles in encouraging mathematical creativity, and they were immediately able to offer several responses, when asked about incorporating tasks that could promote mathematical creativity, there was quiet. Specifically, Ravit and Irit struggled to give examples of tasks that have the potential to occasion mathematical creativity. When they were shown the open tasks, they thought for quite some time if such tasks could be implemented in their classrooms and for which students, making it seem that they were unfamiliar with such tasks. That being said, they were interested to find out how their students with SEN would respond to those tasks. In contrast, Rachel gave an example of a multiple-solution task in geometry (see Figure 1) that she had implemented in her class, in which students are asked to present different ways of finding the area and circumference of a certain polygon.

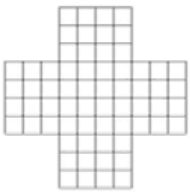
What is the area of the shape? In how many ways can you find the area?	

Figure 1: Rachel's example of a multiple-solution task in geometry

There are several possible explanations for the differences between the teachers. First, Irit and Ravit were trained as special education teachers and gained most of their professional experience in that field, rather than specializing in mathematics. Rachel, on the other hand, had many years of experience as a mathematics teacher, and had only been teaching in special education classes in recent years. Second, the teachers had experience with different age groups. Irit and Ravit taught primary school. Irit attempted to explain why she thought it would be difficult to incorporate such tasks with young students: "Because of the gaps [in knowledge] that are created, I feel that something is always missed somehow … we are in a rush to close those gaps … we are always 'in a war' to make it meaningful and truly develop [students'] thinking, and on the other hand, to complete the curriculum." Irit's thoughts may reflect primary school teachers' perception that primary school mathematics is about acquiring and perfecting basic mathematical skills rather than encouraging mathematical creativity. By contrast, Rachel teaches middle school, where students have more mathematical knowledge, insight, and personal experience, which – alongside the challenge of solving a problem – can encourage mathematical creativity (Silver, 1997). The differences between

the teachers can also be explained as a manifestation of the different approaches to teaching mathematics to students with SEN: the notion that focusing on a handful of calculation procedures and perfecting them is the optimal method of teaching mathematics to students with SEN (Geary, 2003), compared to the approach which states that encouraging students to deal with mathematical challenges and find multiple solution strategies can help even cognitively less proficient students to develop mathematical competence (Jonsson et al., 2014).

Summary and Conclusions

This study investigated the perceptions of three teachers who teach mathematics in SEC regarding mathematical creativity and their roles in fostering mathematical creativity in the classroom. All three teachers expressed the importance of incorporating creativity in SECs. In line with mathematics educators (e.g., Levenson, 2013), they expressed the need to foster an environment which encourages discussion and questioning, and allows students to solve problems in their own ways (Leikin & Lev, 2013). Their responses hinted at their recognition of flexibility and originality.

Like general primary school teachers (Bolden et al., 2010), during the interviews it became apparent that the teachers connected mathematical creativity to students' mathematics comprehension and the way they themselves teach mathematics. Building on this perception, we recommend professional development that would introduce mathematics teachers of students with SEN to various types of tasks that have the potential to occasion mathematical creativity. Teachers can then work together, using their pedagogical knowledge and experience, to integrate such tasks during mathematics lessons. For example, teachers described the importance of using manipulatives to enhance learning. Students with SEN can be encouraged to solve a problem using more than one type of manipulative or even the same manipulative but in different ways, fostering both flexibility and a deeper conceptualization of the topic being learned.

While we acknowledge that this study cannot be generalized, we see our findings as a window into the possibility of fostering mathematical creativity in SEC, offering students with SEN equal opportunities to experience mathematics as a creative domain. Further research might investigate how mathematics teachers in SEC would implement creativity promoting tasks in their classes and how students engage in such tasks, enabling teachers to understand how such tasks can be made accessible to students with different needs.

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