



HAL
open science

Looking for creativity in primary school mathematical tasks

Despina Desli, Marianthi Zioga

► **To cite this version:**

Despina Desli, Marianthi Zioga. Looking for creativity in primary school mathematical tasks. CERME 9 - Ninth Congress of the European Society for Research in Mathematics Education, Charles University in Prague, Faculty of Education; ERME, Feb 2015, Prague, Czech Republic. pp.989-995. hal-01287299

HAL Id: hal-01287299

<https://hal.science/hal-01287299v1>

Submitted on 12 Mar 2016

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Looking for creativity in primary school mathematical tasks

Despina Desli and Marianthi Zioga

Aristotle University of Thessaloniki, Faculty of Education, School of Primary Education, Thessaloniki, Greece, ddesli@eled.auth.gr

The purpose of this study is to explore the features that primary school teachers consider appropriate when choosing tasks intended to promote mathematical creativity. 26 prospective and 48 in-service teachers completed a questionnaire whereby they were asked to choose a mathematical task and explain why it fosters mathematical creativity. Interviews were also conducted with 2 prospective and 2 in-service teachers to further investigate their perceptions of creativity in mathematics as well as issues related to teaching mathematics using creative problems. Disparate views were revealed between the two groups: prospective teachers mostly connect mathematical creativity to arousing student interest whereas in-service teachers connect it to book-oriented problem posing indicating their narrow and blurred perceptions. Outcomes highlight the need for educating teachers about creativity in mathematics.

Keywords: Mathematical creativity, teachers, primary school.

INTRODUCTION

Creativity, traditionally linked to art and literature, has been characterized as an individual activity intended to produce something new (Bolden, Harries, & Newton, 2010). Creativity has also recently been associated with mathematics, it being the ability to create new mathematical insights and ideas (Sriraman, 2009). Similar to this idea, the ability to combine previously known concepts or discover unknown relations between mathematical facts and employ non-algorithmic decision-making can be considered as a creative act of doing mathematics (Ervynck, 1991). Divergent thinking in problem solving is also associated with mathematical creativity (Haylock, 1997; Chamberlin & Moon, 2005). It allows one to analyze a problem from different perspectives without applying one fixed answer, identify patterns, differences and similarities

and choose an appropriate method for tackling it. Although there are many definitions of mathematical creativity, in general, two common trends describe it - the generation of new mathematical knowledge and flexible problem solving abilities (Kwon, Park, & Park, 2006).

Even though the importance of facilitating mathematical creativity in educational settings has been well established, there is a clear need to study the choices teachers make in terms of tasks that could develop children's creativity in mathematics. The present study focuses on the features they consider necessary for mathematical creativity and the reasons for these choices.

RESEARCH BACKGROUND

Mathematical creativity is often assessed on the basis of the four indices of creativity proposed by Torrance (as cited in Silver, 1997) and Guilford (as cited in Klavir & Hershkovitz, 2008). These indices include: a) fluency, referring to the number of correct responses that the student produces, b) flexibility, referring to the number of different mathematical concepts and ideas that the student discovers, usually breaking away from stereotypes, c) elaboration, indicating the complexity of mathematical thinking, as the student integrates different pieces of mathematical knowledge, and d) originality, illuminating the extent that the student's ideas are insightful, new and lead to unexpected and unconventional solutions.

Studies of mathematical creativity have revealed that students' creative mathematical thinking and indices of mathematical creativity could be encouraged by providing divergent product tasks. Klavir and Hershkovitz (2008), for example, suggested tools for teachers to analyze and evaluate the work of fifth-grade students when dealing with an open-ended

problem. These tools referred to indices of mathematical creativity as well as levels of complexity in mathematical knowledge. Their results led them to suggest that open-ended problems tend to distance us from the stereotype that there is only one solution to any given problem and recognized their value as an assessment tool for both teachers and students. Kwon and colleagues (2006) also found that divergent thinking in mathematics could be cultivated through an open-ended approach: in their study with seventh-grade students, open-ended problems were found more cognitively challenging, because they allowed for multiple interpretations and solutions and offered students the opportunity to solve problems using their actual skills. As Mann (2006) suggests, solving these types of problems let the students take the first steps towards mathematical creativity.

The encouragement for promoting children's mathematical creativity in the classroom is advocated in mathematics curricula worldwide that regard it as a desirable outcome of mathematical education. Given the fact that mathematical creativity is also considered as a dynamic faculty that can be improved and enriched or, conversely, decline (Leikin, 2009), great attention has recently been paid to how teachers perceive creativity in mathematics. Bolden and colleagues (2010) found that pre-service teachers in UK hold narrow conceptions regarding creativity in mathematics: these conceptions are mainly associated with the use of resources and technology and, while attempting to create a 'fun' environment, they 'teach creatively' rather than 'teach for creativity'. Their great difficulty in recognizing creativity in teaching mathematics and also in identifying ways of encouraging it in the classroom was also observed. More positive results were revealed in Chiu's study (2009), which found that in-service teachers profess a greater preference for creative problems, compared to non-creative problems for teaching fractions: a liberal approach was proposed as the most appropriate method for teaching creative problems with emphasis on the children's imaginative and diverse solutions. Secondary classroom teachers, however, identified both opportunities and constraints in posing more challenging mathematical tasks, especially those related to changes to their pedagogies and assessment of student work (Sullivan & Mornane, 2014).

However, a key component of mathematical creativity is how teachers select and use appropriate tasks which

enhance children's creativity in terms of school mathematics. In her study, Levenson (2013) investigated general trends that prospective and in-service teachers attribute to tasks that may occasion mathematical creativity. Of these trends, the most common one was the implication that creativity pertains to being different and unusual. The responses of participants also focused on the cognitive demands of the chosen tasks, as well as their affective aspect. Interestingly, with regards to the latter, teachers took into consideration possible feelings which a task may elicit from students.

These studies suggest that excluding the teachers as important factors in determining the use of creative mathematics problems in the classroom could lead to an incomplete understanding of the situation. Thus, investigating teachers' perspectives of creativity in primary mathematics, by asking them to choose such tasks is important, in order to understand the knowledge they hold that could influence their interpretation of creativity in the curriculum and what they do in their teaching. Specifically, this study attempted to examine the following questions: a) Which task characteristics do prospective and in-service primary school teachers associate with the promotion of mathematical creativity?, b) Are there any discrepancies between the task characteristics identified by prospective teachers and in-service teachers?, and c) How they envision creativity being taught in the mathematics classroom?

METHOD

Participants. Twenty-six prospective teachers and forty-eight in-service teachers participated in the study. At the time of the study, prospective teachers, who were in their last year of an elementary teaching education programme at a large-sized university in Thessaloniki, participated in a course on teaching mathematics that was mainly focused on observing, planning and teaching mathematics in local primary schools. They were predominantly women (92%) with a mean age of 22 years and 2 months. In-service teachers, most of which were women (83%) with a mean teaching experience of 18 years, worked at several grades of state primary schools from various geographical regions of Northern Greece and their ages ranged from 26 to 58 years old. A small percentage of in-service teachers (15%) who took part in the study had completed postgraduate studies, but did not mention that they have attended specific training courses

on creativity. All participants' selection was random and their participation was voluntary.

Instrument. Data were collected via a questionnaire and semi-structured interviews. The questionnaire used was based on Levenson's (2013) research tool and asked participants to: a) choose a task that they consider appropriate for promoting mathematical creativity. This task could be from either the state mathematics textbooks or any mathematics book or even one proposed by themselves., b) indicate their source, c) state the grade to which the task is targeted and whether it is intended for individual or group work, and d) describe why they consider the task they had chosen suitable for promoting mathematical creativity. All questions in the questionnaire were open-ended and no possible answers were provided. Additionally, no instruction about the term 'task' was given to participants who were free in their interpretation. However, the present study relies on Stein and Smith (1998), who clarified the multiple roles of tasks: these may be set up by teachers during their instruction as learning tasks, review tasks, practice and assessment tasks with the main purpose of developing a particular mathematical idea.

Follow-up interviews were conducted on the basis of the questions developed from the completed questionnaires. Thus, supplementary data were gathered, in order to verify that questionnaire responses were being interpreted as they were initially intended. Interview questions explored the participants' envision of creativity in mathematics and the use of creative problems in teaching mathematics in primary schools. In the present study the results of only two prospective and two in-service -randomly chosen- teachers are presented as these were the first interviewed and became part of a larger sample for the purposes of a later relevant study.

Procedure. The questionnaires were administered to prospective and in-service teachers during their classes, at the University and the schools, respectively, and they were collected after two weeks. The majority of those contacted returned the completed questionnaires, reaching 93% and 89% participation response rates for prospective and in-service teachers, respectively.

Interviews were conducted individually at a place convenient to interviewees, two weeks after they had

completed the questionnaires, and lasted approximately 20 min.

RESULTS

The results are presented in two main sections. It is not possible to present all the tasks proposed by the participants in this paper, therefore only three are presented in the first section. In the second section we describe common trends in the responses of participants, drawn from answers to the questionnaire and the interviews, regarding the teaching of mathematics and learning with creative problems.

a. Tasks proposed by the participants. The majority of the tasks the participants chose were taken from the mathematics textbooks that are given to all students in the nation (85% and 83% for prospective and in-service teachers, respectively). Only one in-service teacher seized the opportunity to propose a task herself and handed in a task that was her own devising. Prospective teachers proposed about 40% of the tasks for individual work, whereas the rest of the chosen tasks were divided equally for either group work or both individual and group work. Great preference for tasks carried out individually (42%) – rather than for all students (38%) – was also observed by in-service teachers.

Katerina, a prospective teacher, chose the task shown in Figure 1, taken from a Grade 2 mathematics student book, and proposed that children could work on it individually. The task in question is special because it does not provide students with a familiar methodology for solving it. Katerina mentioned it in her response and explained why this task promoted mathematical creativity: *'it is a task that cannot be easily solved in the usual way. It doesn't use typical formulas... children will experience the struggles of finding explanations and solutions... it leads to creative thinking'*. Even the opportunity to use a trial-and-error strategy when solving the problem was seen as conducive to mathematical creativity. For her, mathematical creativity was associated with breaking away from well-trodden paths. However, she did not mention the fact that there are several ways of solving this problem, a characteristic that raises flexibility as involved in creativity. Last, she put great emphasis on the story involved (toy cars) and believed that anything that motivates students to work – indicating mainly the problem story – can promote creativity.

Ο Νικόλας έχει 20 αυτοκινητάκια μπλε, κόκκινα και μοβ.
 Τα μπλε είναι όσα και τα κόκκινα. Τα μοβ είναι τα λιγότερα.
 Πόσα αυτοκινητάκια μπορεί να είναι:

μπλε
 κόκκινα



Υπολογίζω με αριθμούς:

Nikolas has a total of 20 blue, red and purple toy cars. Blue cars are as many as red ones, purple cars are less. How many are the blue and red cars? Compute with numbers.

Figure 1: Katerina's task

Διατυπώνω δικά μου προβλήματα σύμφωνα με τις εικόνες.



.....

.....

Make your own problems that suit the pictures.

Figure 2: Anna's task

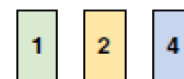
The task in Figure 2 was proposed by Anna, an in-service teacher. It was taken from a Grade 1 mathematics workbook and it was meant for all students to solve. Anna mentioned three components she believes are promoted by the task. First, every child may phrase and create her own problem and, thus, may take an active part in solving it. In this sense, 'every child may bring her interests into mathematics and feel involved'. Although this feature calls mostly on the

emotional impact that a task may have on children, Anna raises the issue of the mathematical content involved. According to her, 'children may see addition or subtraction involved, insert numbers and perform calculations'. This feature, though, is more reminiscent of a conventional problem that requires certain ordered steps to reach algorithmic answers. Third, she acknowledges that the fact that children can pose different problems leads them to different solutions that may encourage debates and contribute to a productive classroom discussion.

Figure 3 shows a prospective teacher's choice of a creative mathematical task, taken from a Grade 6 mathematics workbook. Maria's activity includes four mini questions -each of which is meant to have one and only one algorithmic solution- that do not require new ideas. It may be conducted in the classroom using pen and paper and by following steps in a specific order. However, this fact did not deter Maria from considering this task as one promoting creativity. Instead, she considered the fact that children are asked to act (e.g. by moving the cards), are presented with the mathematical knowledge and communicate their findings as important. The fact that some features are overestimated or others are ignored is often the case, as it happens with Maria's choice.

b. Participants' reasons for choosing tasks. Participants listed various reasons for choosing their task. Because they provided more than one reasons, these are analyzed on the basis of the number of participants (see Table 1). Attractive and entertaining stories (30,8%) involved in the task that may arouse children's interest and inquiry was one of the two most important elements for fostering mathematical creativity, according to prospective teachers. Creative mathemat-

Κόψτε 3 κάρτες με τους αριθμούς 1, 2 και 4 όπως αυτές που απεικονίζονται στο διπλανό σχήμα.



Χρησιμοποιώντας όλες τις κάρτες και το μολύβι σου για γραμμή του κλάσματος επάνω στο θρανίο να σχηματίσετε με την ομάδα σας τα εξής:

- Το μικρότερο δυνατό κλάσμα
- Το μεγαλύτερο δυνατό κλάσμα
- Ένα κλάσμα ισοδύναμο με το $\frac{1}{3}$
- Ένα κλάσμα ισοδύναμο με 3

Cut three cards and place numbers 1, 2 and 4 on them, as shown in the figure. Using all cards and marking a fraction line with your pencil, work in groups and make: the smallest possible fraction, the biggest possible fraction, a fraction equal to 1/3, a fraction equal to 3.

Figure 3: Maria's task

ical tasks were also those that allow children to make their own constructions (30,8%), placing emphasis on the children's active engagement in mathematical activities, as well as those that invite work between students and encourage cooperative learning (23%).

In-service teachers seem to relate creativity to the activity of problem-posing on the part of the children (37,5%) and the placement of the task in a real-life context (16,7%) that may offer opportunities for the flexible use and application of mathematics in everyday life. However, many in-service teachers insisted on more 'traditional' ideas: these tied creativity to solution methods provided from the start and presented in multiple steps following an hierarchical order (29,1%) and focused on algorithmic thinking and techniques (20,8%).

Both groups of participants mentioned creativity in terms of searching for new ways to cope with mathematical problems on the basis of their previous mathematical knowledge (23% and 8,4% for prospective and in-service teachers, respectively). Presenting children with unusual questions (quizzes were the most frequently mentioned) was connected to motivation for imagination and creativity (23% and 20,8% for the two groups). Interestingly, prospective teachers only seem to regard that difficult technical calculations are not necessarily required; they view mathematical creativity as not being constrained by precise methods or anticipated outcomes and support non-algorithmic

thinking and computational estimation (8,5%). Last, seeing the same problem offering several different solutions as well as connections with other, less (or non-) mathematical, school subjects were also considered to elicit mathematical creativity.

DISCUSSION

The characteristics participants associated with mathematical creativity, as shown in the aspects they considered in choosing tasks, demonstrated predominantly that both prospective and in-service teachers identify creativity in primary mathematics classrooms. Based on the mathematical tasks they chose, however, it was revealed that identifying mathematical creativity was not an easy thing to do. Interviews further confirmed the participants' difficulties in being clear about planning and encouraging creativity in the classroom. Although they seem to believe that mathematics can be a subject that is offered for the promotion of creativity in children, however, they acknowledge constraints in the classroom, mainly related to the role of the teacher and the mathematical content.

There were some common ideas between the two participant groups, but the issue of mathematical creativity and how this can be fostered drew disparate views, which were probably influenced by their academic training. Prospective teachers mostly related mathematical creativity to arousing children's interest and

Elements of tasks that promote mathematical creativity	Prospective	In-service
	Teachers	
Story that arouses children's interest and inquiry	30,8%	8,4%
Problem-posing by children		37,5%
Children construct (e.g., draw, combine shapes)	30,8%	8,4%
The solution method is provided in multiple steps	15,4%	29,1%
Presenting with unusual questions	23%	20,8%
Connections between mathematical topics and everyday life	23%	16,7%
Use of manipulatives	23%	12,6%
Use and extension of previous knowledge	23%	8,4%
Children work together – Cooperative learning	23%	
Focus on algorithmic thinking and techniques	7,7%	20,8%
Large number of possible solutions to a problem	15,4%	8,4%
Focus on computational estimation	8,5%	
Connections with other school subjects	7,7%	4,2%
Other	3%	4,2%

Table 1: Characteristics identified for tasks that promote mathematical creativity by prospective and in-service teachers

motivation, mainly with the use of attractive stories or puzzles that keep them engaged in mathematics. This finding is in agreement with Bolden and colleagues' (2010) results that, for prospective teachers, creativity was bound up with the use of resources in order to create a 'fun' environment for children. Although this might be a desirable outcome, care is needed to avoid underestimating children's access to mathematical ideas. Prospective teachers also gave emphasis on children's own constructions when doing mathematics, use of materials and non-algorithmic thinking. It is encouraging to see prospective teachers moving away from a conservative view of mathematics with algorithmic calculations. This orientation that brings flexibility to the front was also observed in Bolden and colleagues' (2010) study. In general, prospective teachers recognize some of the aspects of creativity as do researchers (Klavir & Hershkovitz, 2008; Levenson, 2013; Kwon et al., 2006). Last, cooperative work was often considered necessary for the promotion of mathematical creativity; children working on a task may contribute insights, experiences and ideas building eventually to a solution brought forth by more than one student. The issue of collective mathematical creativity was originally raised by Levenson (2011) who deems it equally important as individual mathematical creativity.

In-service teachers, on the other hand, related mathematical creativity to children's problem posing. They explain that asking children to make up a problem provides them with the opportunity to feel involved and take an active role in solving their own problem. Other elements they considered as important referred to applying some algorithm learned in class and following strictly-defined steps towards a solution method. These were limited to rule-based applications and were relatively different from what researchers consider as mathematical creativity. Their choices of tasks, in general, were less imaginative without recognizing the essence of the problem to be solved, and indicated their narrow and blurred perceptions. Thus we wonder how easily a teacher may overestimate the more conservative aspects of teaching and discard the opportunities for mathematical creativity that a task might provide. Searching for the new in mathematics and expressing the unusual have also been considered by a few participants who highlighted novelty and placed emphasis on creativity in mathematics. These participants raised issues such as real-life connections to mathematics, connections with other

school subjects and extension of previous knowledge. Unusualness as an element for creativity was strongly supported by the use of non-routine problems (e.g., quizzes), non-standard problems that involved unexpected and unfamiliar solutions (Yeo, 2009).

An additional finding of the study showed that although participants identified characteristics of mathematical creativity in general, these characteristics were not always revealed in the tasks they had chosen or did not fit well with their choices of tasks. For example, a few participants regarded multiple solution methods as a key element to creativity. Although searching for different solutions can definitely be seen as an aspect of both flexible thinking and fluency, its value is mediated, if an explicit direction to consider several different ways of solving the problem is given at the end of the task. The demand to solve a task using different methods may have the opposite effect on creativity. Similarly, in the search for a task that may foster children's mathematical creativity, the vast majority of the participants searched for tasks taken from standard classroom textbooks. This may be interpreted in two ways: participants are unwilling to look for tasks other than those provided, or, less pessimistically, participants may transform any task to a creative one, depending on how they themselves implement it in the classroom. Although attention to the nature of mathematical tasks that foster mathematical creativity is important, an equal level of it in the classroom processes associated with mathematical creativity is needed. We are aware that analyzing only the tasks chosen by the participants is an inadequate method for predicting if the lessons would run for the purpose of teaching for creativity. Further investigation of this topic is needed.

The findings from this study suggested that the awareness of prospective and in-service teachers in terms of choosing tasks that promote mathematical creativity was apparent, at least at its manifested level; however, encouraging creativity in primary mathematics classrooms can generally be an elusive accomplishment. There is a need for clarification on how the idea of mathematical creativity is implemented and referred to in a mathematics lesson. This leads to the need for providing teachers with opportunities to be educated in mathematics teaching for creativity.

REFERENCES

- Bolden, D.S., Harries, T.V., & Newton, D.P. (2010). Pre-service teachers' conceptions of creativity in mathematics. *Educational Studies in Mathematics*, 73, 143–157.
- Chamberlin, S.A., & Moon, S.M. (2005). Model-eliciting activities as tool to develop and identify creativity gifted mathematicians. *Journal of Secondary Gifted Education*, 17(1), 37–47.
- Chiu, M-S. (2009). Approaches to the teaching of creative and non-creative mathematical problems. *International Journal of Science and Mathematics Education*, 7, 55–79.
- Ervynck, G. (1991). Mathematical creativity. In D. Tall (Ed.), *Advanced mathematical thinking* (pp. 42–52). New York: Kluwer Academic Publishers.
- Haylock, D. (1997). Recognising mathematical creativity in schoolchildren. *ZDM: The International Journal on Mathematics Education*, 29(3), 68–74.
- Klavir, R., & Hershkovitz, S. (2008). Teaching and evaluating 'open-ended' problems. *International Journal for Mathematics Teaching and Learning*. Retrieved from: <http://www.cimt.plymouth.ac.uk/journal/default.htm>
- Kwon, O.N., Park, J.S., & Park, J.H. (2006). Cultivating divergent thinking in mathematics through an open-ended approach. *Asia Pacific Education Review*, 7(1), 51–61.
- Leikin, R. (2009). Exploring mathematical creativity using multiple solution tasks. In R. Leikin, A. Berman, & B. Koichu (Eds.), *Creativity in mathematics and the education of gifted students* (pp. 129–135). Rotterdam: Sense Publishers.
- Levenson, E. (2011). Mathematical creativity in elementary school: is it individual or collective? In *Proceedings of the 7th Congress of the European Society for Research in Mathematics Education (CERME)*. Rzeszow, Poland.
- Levenson, E. (2013). Tasks that may occasion mathematical creativity: teachers' choices. *Journal for Mathematics Teacher Education*, 16, 269–291.
- Mann, E.L. (2006). Creativity: The essence of mathematics. *Journal for the Education of the Gifted*, 30(2), 236–260.
- Silver, E. (1997). Fostering creativity through instruction rich in mathematical problem solving and problem posing. *ZDM: The International Journal on Mathematics Education*, 29(3), 75–80.
- Sriraman, B. (2009). The characteristics of mathematical creativity. *ZDM: The International Journal on Mathematics Education*, 41 (1–2), 13–27.
- Stein, M.K., & Smith, M.S. (1998). Mathematical tasks as a framework for reflection: From research to practice. *Mathematics Teaching in the Middle School*, 3(4), 268–275.
- Sullivan, P., & Mornane, A. (2014). Exploring teachers' use of, and students' reactions to, challenging mathematics tasks. *Mathematics Education Research Journal*, 26(2), 193–213.
- Yeo, K.K.J. (2009). Secondary 2 students' difficulties in solving non-routine problems. *International Journal for Mathematics Teaching and Learning*, 10, 1–30.