STRATEGIES PROPOSED BY PRESERVICE TEACHERS TO FOSTER THEIR STUDENTS' CREATIVITY

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In this study, we aim to analyse the preservice teachers' perspectives on creativity, in particular, if they consider that creativity can be developed, and their strategies to foster students' creativity. The participants are 43 preservice teachers who were taking a master's degree to become teachers of secondary school. The master's program did not include a specific training in creativity. They answered a questionnaire about creativity and then three of them were interviewed. We did a content analysis of their answers. Most of the preservice teachers think that creativity can (and should) be developed in the mathematics classroom. They suggest different strategies to foster students' creativity that agree with literature, but solving open-ended problems stands out among the rest of strategies.

INTRODUCTION

The research interest in creativity has increased in the last decades (Joklitschke et al., 2018). At the same time, the view of creativity as an ability that can be developed and that is related to the learning processes, instead of being just an innate and uncommon ability, has spread among researchers and education professionals (Beghetto & Kaufman, 2007). In particular, creativity is associated with mathematical processes, such as problem posing and problem solving (Mann, 2006). Therefore, mathematics teaching and learning processes should include the development of students' creativity in order to be meaningful for them; however, this rarely happens in practice (Luria et al., 2017). Yazgan-Sağ and Emre-Akdoğan (2016) highlight that teachers should be aware of the importance of creativity and how to enhance it in their lessons.

This study is part of a research about the secondary school preservice teachers' perspectives on creativity and its enhancement in mathematics classroom, when they are not specifically trained to develop their students' creativity. The context of this research is a master's program in teaching in secondary school (specialization of mathematics), which does not include a specific training in creativity. In this paper, we aim to answer these questions: 1) Do preservice teachers think that creativity can (and should) be developed at school? 2) Which strategies do they propose to enhance students' creativity?

THEORETICAL FRAMEWORK

In this section, we briefly review some previous research on strategies to enhance students' creativity in the mathematics classroom and research on the conceptions of creativity of preservice and in-service teachers.

Strategies to enhance creativity

There are several research on how to foster students' creativity. In particular, in the mathematics classroom, Silver (1997) suggests that the students' work should be more similar to the work of a mathematician, including problems solved and posed by the students. Some authors focus on the characteristics of the problems; for example, Sitorus and Masrayati (2016), with Realistic Mathematics Education; or Chamberlin and Moon (2005), with model-eliciting activities. Moreover, according to some authors, creativity can be related to processes such as visualization, exploration, making conjectures or argumentation that can be enhanced with the use of physical (Siew & Chong, 2014) and virtual manipulatives (Yildiz et al., 2017). Other strategies to foster creativity at school are enhancing the students' interaction, since verbalizing ideas is useful to structure them and generate new connections (Fischer, 2004; Levenson, 2011), and using an informational evaluation (Amabile and Pillemer, 2012).

Teachers' conceptions of creativity

In order to provide the students with the opportunity of developing their creativity, first, teachers should be aware of the importance of developing students' creativity, as Yazgan-Sağ and Emre-Akdoğan (2016) suggest. They compared the answers of four prospective teachers of mathematics and one of their educators about the actions that define a creative teacher. The prospective teachers highlighted the characteristics of the activities that the creative teacher would propose (use of different resources, real-life or open-ended problems, etc.), whereas the teacher educator gave more relevance to the thinking processes and explained that a creative teacher enables students to solve problems autonomously. Another example of research with preservice teachers is the study of Vanegas and Giménez (2018). They included a specific training in creativity for early childhood preservice teachers. We also found some research on the conceptions of creativity of in-service teachers (e.g., Cheng, 2010; Leikin et al., 2013, Lev-Zamir & Leikin, 2013). Cheng (2010) did an action research with seventy-five primary school teachers. They had to implement creative teaching in their schools and then they explained the tensions and dilemmas that they had experienced. Leikin et al. (2013) reported the results of a questionnaire answered by 1089 teachers from six countries. The questions were about the characterization of a creative student and a creative teacher, the relation between creativity in mathematics and culture and participants' general view of creativity. Lev-Zamir and Leikin (2013) studied the differences between the teachers' declarative conceptions of creativity and their conceptions-in-action.

METHODOLOGY

We used a qualitative methodology, based on the interpretation of the preservice teachers' answers to a questionnaire and some interviews about their perspectives on creativity and its development at school.

Context and participants

Forty-three preservice teachers, who were taking a master's program in teaching in secondary school (specialization of mathematics) in the year 2017-2018, voluntarily answered the questionnaire. Afterwards, three of them (P1, P2 and P3) were interviewed. The questionnaire was implemented after the period of teaching practice of the master's program; therefore, the participants already had some teaching experience, though scarce. At the end of the master's program, the preservice teachers present a master's final project (MFP), where they reflect on their teaching practice, assess it and propose some improvements for the learning sequence that they implemented. The MFP of the three preservice teachers that participated in the interviews, at the end of the course, were considered in the design of their interviews.

The questionnaire and the interviews

We adapted a questionnaire used in previous research (Seckel et al., 2019) to the specific context of the master's program. The questionnaire has 26 Likert questions and 5 open-ended questions. The Likert questions used a 5-point scale and were structured in the following topics: characteristics of creativity and creative thinking; the elements of a creative process; characteristics of a creative student; characteristics of a creative teacher; elements to enhance mathematical creativity in the classroom; and the impact of enhancing creativity in the classroom. The open-ended questions were about: the characteristics of a mathematical activity that enhances students' creativity; general strategies to foster creativity in the classroom; an example of activity; the importance that designing these activities should have within the teachers' work; and whether this topic was present in the master's program and how. The last question was posed to check our supposition that the master's program did not include a specific training in creativity, although some ideas about the enhancement of creativity could have been commented in the sessions.

At the end of the course, we interviewed three preservice teachers that had previously answered the questionnaire. The interview was semi-structured and had two parts. In the first part, we asked the participants about their definition of creativity, especially in school context, the characteristics of a student's creative work, the importance of fostering creativity and the difficulties to do it. In the second part of the interview, we used some comments related to creativity that had been previously identified in the MFP of each participant. We asked the preservice teachers to explain their comments and whether they considered that they could foster students' creativity with the tasks that they had proposed in the MFP. We also asked them about other strategies to enhance creativity. In this work, we focus on whether participants think that creativity is an innate ability or can be developed, and the strategies that they propose to enhance students' creativity in the classroom.

Analysis of the participants' answers

In order to analyse the answers to the questionnaire, first, we considered the questions separately. With the Likert questions, we calculated the percentages of answers in each level of the scale. Then, we did a content analysis (Miles & Huberman, 1994) of the answers to the open-ended questions. We generated categories of answers in the first, second and fourth open-ended questions. The answers to the third question were compared to the answers in the first and second questions. In the fifth question, we could identify some subjects of the master's program where, according to the preservice teachers, some ideas about creativity and creative work in secondary school had been introduced. In a second phase of analysis, we compared each participant's answers to the questionnaire, organizing the questions using the dimensions of the didactic suitability criteria (DSC) of the Onto-Semiotic Approach (Breda et al., 2017; Godino, 2013). The DSC enabled us to consider the different dimensions of a teaching and learning process (epistemic, cognitive, mediational, affective, interactional and ecological) and classify the strategies to foster creativity that the preservice teachers propose, based on these dimensions. The DSC were used similarly in the research of Seckel et al. (2019). Moreover, the comparison of each participant's answers was useful for detecting possible inconsistencies between the answers to the Likert questions and the answers to the open-ended questions. In these cases, the answers were not considered in the report of the results.

Then, we did a content analysis of the three interviews. Regarding the strategies that the preservice teachers proposed to enhance creativity, we used the DSC again to classify the strategies. The interviews complemented the results of the questionnaire.

RESULTS AND DISCUSSION

Based on the results of the questionnaire, most of the preservice teachers (69.7%) consider that creativity can be developed, though some of them (11.6%) disagree with this view (Table 1). In addition, seven participants agree with both statements A.1.1 (creativity is an innate ability) and A.1.2. (creativity can be developed). On the other hand, most of the preservice teachers do not think that creative thinking is a consequence of exceptional moments of inspirations, but they do not relate it to a thoughtful analysis of a problem either. Similar results are reported by Seckel et al. (2019), whose participants were in-service teachers.

A.1. What characterizes creativity and creative thinking?	1 %	2 %	3 %	4 %	5 %
1. Creativity is an innate ability or quality.	11.6	25.6	30.2	20.9	11.6
2. Creativity is a quality that can be developed, trained, etc.	0.0	11.6	18.6	30.2	39.5
3. Creative thinking is a consequence of exceptional moments of inspiration.	14.0	39.5	25.6	16.3	4.7

4. Creative thinking is associated with a long and thoughtful process of study of a problem.	18.6	20.9	30.2	27.9	2.3

Table 1: Percentages of answers to some Likert questions of the questionnaire. (In this scale, 1 = strongly disagree, 2 = disagree, 3 = not agree nor disagree, 4 = agree, and 5 = strongly agree).

In general, preservice teachers consider that enhancing creativity in the mathematics classroom is something positive (Vanegas & Giménez, 2018), because it makes the students like the subject more (33 participants, 76.7%), learn more (33 participants, 76.7%) and work more (28 participants, 65.1%). Some of the participants (11.6%) think that it is important to develop students' creativity because this prepares them better for their future jobs and society.

Regarding the strategies that the preservice teachers propose to enhance students' creativity, most of them are related to the epistemic dimension. They suggest to enhance creativity through activities that are rich in mathematical processes (Mann, 2006; Chamberlin & Moon, 2005; Silver, 1997), especially solving problems and open-ended tasks (30 participants mention it in the questionnaire). Some participants also mention that the tasks should be contextualized (Sitorus & Masrayati, 2016), include interdisciplinary connections, and let the students pose their own mathematical questions and make conjectures.

Considering the cognitive dimension, some preservice teachers explain that the tasks should be adapted to the diversity of students' mathematical level. For example, P24 says that the task should be "affordable for the different learning rhythms", with "clear and short objectives" and "motivating". Moreover, some participants mention that the task should be challenging for the students. Regarding the assessment of students' learning, P34 suggests that the teacher "assesses aspects that are not usually assessed", without specifying which aspects should be considered. In the interviews, we asked preservice teachers if the assessment could enhance students' creativity. P3 thinks that the assessment process determines a lot if students are more or less creative. He explains that the fact that students get responsible with their work and their learning process leads to foster more creative answers or processes and suggests the use of personal learning journals. P2 says that the assessment can foster creativity, but he does not know how to do it. On the other hand, P1 responds that the assessment cannot foster creativity, but affect it negatively:

P1: For me, one of the main problems is that students study just for the final result, not for the knowledge. Then, the assessment does not foster creativity, it fosters competitiveness and willingness to have a better mark, but not creativity. (…)

Interviewer: Okey. But assessment is a broad concept. (…) There is also the formative assessment and other things…

P1: Exactly. Well, it would not foster it [creativity] either. (…) Could it consider it [creativity]? Yes, it could, but it does not foster it [creativity]. (…) No, because then you would try to force it and creativity should be something that appears spontaneously.

We could observe a relation between the interviewed preservice teachers' ideas about assessment and their ideas about students' responsibility, that may also explain their reflections on whether assessment can foster creativity or not. P3 relates responsibility to creativity; whereas, P2 and P1 do not relate these terms and P1 justifies that the students' responsibility is studying what they are told to. As Amabile and Pillemer (2012) highlight, using the assessment as an extrinsic motivation does not usually foster the development of creativity; in contrast, an informational assessment can help to enhance students' creativity.

Nineteen participants suggest the use of manipulatives (mediational dimension) to enhance students' creativity, since manipulatives can help them to visualize a mathematical object and its properties (Siew & Chong, 2014; Yildiz et al., 2017). For instance, P14 explains that the use of physical manipulatives or learning and knowledge technologies "allow for experimentation to discover". In the interviews, P2 and P3 say that the use of manipulatives can also motivate the students and this boosts their creativity (affective dimension). Indeed, in the questionnaire, most of the preservice teachers (65.1%) agree both that motivation boosts creativity and that enhancing creativity makes the students like the subject more, indicating a possible positive feedback between creativity and motivation. Cheng (2010) identifies a similar relation between creativity and motivation (though expressed in negative terms), based on the answers of in-service teachers: when students are not used to work creatively in the classroom, they have more difficulties to respond to tasks that aim to enhance their creativity, then they maintain their previous learning habits and are less motivated; at the same time, if they have a low motivation, they tend to participate less in the classroom, which hinders the development of creativity.

Thirteen preservice teachers propose enhancing students' participation in the classroom as a strategy to foster the development of their creativity (Sitorus & Masrayati, 2016). Other strategies of the participants related to the interactional dimension are working in little groups (Fischer, 2004; Levenson, 2011), giving freedom to the students and fostering students' autonomy. In the interviews, P2 and P3 mention that the work in groups may enhance creativity; however, P1 does not think the same way. For him, when the teacher proposes an activity to work in groups, the students divide the work and there is not a real interaction between them.

Finally, most of the preservice teachers (93%) consider that the teacher's attitude affects the enhancement of students' creativity. In addition, eight participants indicate in the open-ended questions that the teacher should have an open and positive attitude (Levenson, 2011; Sitorus & Masrayati, 2016), three participants say that the teacher should have an open but critical attitude, and two participants think that the teacher

should like the activities that they implement. The latter aspect is also identified in previous research with in-service teachers (Cheng, 2010; Leikin et al., 2013).

CONCLUSIONS

Although the preservice teachers did not receive a specific training in creativity, most of them assume that students' creativity can be developed at school and that it is something positive. They propose several strategies to foster creativity that are coherent with literature. In particular, most of them associate the enhancement of creativity in the mathematics classroom with problem solving. However, less than half of the preservice teachers explain an activity to enhance students' creativity in the third open-ended question of the questionnaire. This may suggest that the strategies that they recognize in theory are not incorporated into their teaching practice. In this sense, Lev-Zamir and Leikin (2013) also detect a gap between teachers' declarative conceptions of creativity in mathematics teaching and their conceptions-in-action.

Moreover, we observe that some strategies, such as working in little groups and using the assessment to foster creativity, are not so often assumed among the participants. Assessment seems to be a key aspect, since depending on how it is designed it could enhance or hinder students' creativity (Amabile & Pillemer, 2012). These results may be useful to design a specific training in creativity for preservice teachers that strengthens their skills to design tasks that foster students' creativity and focuses on those aspects that they usually find more difficult to manage in the classroom.

Acknowledgement

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