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Kindergarten teachers' knowledge in and for interpreting students' productions on measurement	3986
<i>Milena Policastro, Miguel Ribeiro and Alessandra Rodrigues de Almeida</i>	
Developing an identity as a secondary school mathematics teacher: Identification and negotiability in communities of practice	3988
<i>Kirsti Rø</i>	
Students abilities on the relationship between beliefs and practices	3996
<i>Safrudiannur, and Benjamin Rott</i>	
Secondary school preservice teachers' references to the promotion of creativity in their master's degree final projects	4004
<i>Alicia Sánchez, Vicenç Font and Adriana Breda</i>	
The problem of 0.999 &: Teachers school-related content knowledge and their reactions to misconceptions	4012
<i>Verena Spratte, Laura Euhus and Judith Kalinowski</i>	
"In school you notice the performance gap and how different it is between the students" - Student teachers' collective orientations about the learners' heterogeneity in mathematics	4020
<i>Ann-Kristin Tewes, Elisa Bitterlich, Judith Jung</i>	
Teachers noticing of language in mathematics classrooms	4028
<i>Carina Zindel</i>	
<b>TWG21: Assessment in mathematics education</b>	<b>4036</b>
Introduction to the papers of TWG21: Assessment in mathematics education	4037
<i>Paola Iannone, Michal Ayalon, Johannes Beck, Jeremy Hodgen and Francesca Morselli</i>	
Strategies of formative assessment enacted through automatic assessment in blended modality	4041
<i>Alice Barana and Marina Marchisio</i>	
National standardized tests database implemented as a research methodology in mathematics education. The case of algebraic powers.	4049
<i>Giorgio Bolondi, Federica Ferretti, George Santi</i>	
Students' attitudes and responses to pair-work testing in mathematics	4057
<i>Eszter Bóra and Péter Juhász</i>	
Classroom assessment tasks and learning trajectories	4059
<i>Eleni Demosthenous, Constantinos Christou and Demetra Pitta-Pantazi</i>	
Diagnosis of basic mathematical competencies in years 8 and 9	4067
<i>Christina Drüke-Noe and Hans-Stefan Siller</i>	
Assessment and argumentation: an analysis of mathematics standardized items	4075
<i>Rossella Garuti and Francesca Martignone</i>	
Evaluating students' self-assessment in large classes	4083
<i>Jokke Häsä, Johanna Rämö and Viivi Virtanen</i>	

## Secondary school preservice teachers' references to the promotion of creativity in their master's degree final projects

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*What do preservice teachers think about creativity and the ways to promote it in their classes? In this study, we analyze the references to creativity that appear in the master's degree final projects of a group of secondary school preservice teachers of mathematics. The projects hold the preservice teachers' reflections on their own practice, but it is important to note that the master's degree does not include any specific training in creativity. In our analysis, we first searched for explicit references to creativity in the projects and registered them. Then, we classified the comments depending on the elements of the teaching and learning process that are related to creativity in each case. We observe a good variety of comments and more than half of the preservice teachers mention creativity, although some of them just do it superficially.*

*Keywords: Preservice teachers, creativity, master's degree final project, didactic suitability.*

### Introduction

In recent years, creativity has become an important focus of interest of social sciences. Creativity could be related to the development of other abilities such as critical thinking, problem solving, communication and the use of new technology, current challenges in the globalized society (Pásztor, Molnár, & Csapó, 2015). In education, creativity has also gained importance and its development is a goal in modern curricula (Pásztor et al., 2015). In addition, many authors (Mann, 2006; Silver, 1997; Sriraman, 2005) claim that creativity should be fostered at school by inclusive activities, working with every student and not only with those considered gifted students. However, mathematics lessons at school are commonly associated with repetitive procedures and regardless of students' creativity.

Research on the promotion of students' creativity by improving the teachers' training (Hosseini & Watt, 2010; Panaoura & Panaoura, 2014) and research on teachers' conceptions of creativity (Lev-Zamir & Leikin, 2011) disregards the following question: how do the teachers consider the promotion of students' creativity in their learning sequences, when they do not receive specific training in this subject? In order to answer this question, in this study, we focus on how preservice teachers conceive the promotion of students' creativity when they analyze their own practice and propose some changes to improve it, in their master's degree final projects.

### Theoretical framework

There are several definitions and conceptualizations of creativity (Kampylis, & Valtanen, 2010; Kaufman, & Sternberg, 2006). Kaufman and Beghetto (2009) propose a model with different types of creativity: Big-C, which refers to eminent people whose creations have had an impact on a field; little-c, which is associated with everyday creativity which appears in daily activities; Pro-C, which is present in those professional activities that are generally considered specially creative; and mini-c, which they define as "the novel and personally meaningful interpretation of experiences, actions, and events" (Beghetto & Kaufman, 2007, p.73). Mini-c creativity is related to learning processes, since it

implies a personal interpretation of new facts based on previous experiences and knowledge. In our research, we consider the development of creativity at secondary school level, so we use the term in accordance with the definition of mini-c creativity.

Then, a question emerges: how is creativity generated in a teaching and learning process? Regarding this question, the first step is assuming that creative thinking is a complex process that can be studied as a process that emerges from others, as Malaspina and Font (2010) explained with the intuitive process. These authors propose that a method to investigate complex processes is decomposing them into more simple processes and they use the metaphor of the vector space: the more complex process, creative thinking in this case, can be understood as a linear combination of the basis vectors (other processes). This approach to creativity as a process emergent from other more simple processes, was also considered in the European project *A Computational Environment to Stimulate and Enhance Creative Designs for Mathematical Creativity (MC2)* (Sala, Font, Barquero, & Giménez, 2017):

Then, when we concluded that the way to conceptualize the creative process in mathematics is decomposing it into other processes, we considered, together with the MC2 team, that the best way to go further in its study was adopting the method proposed by the Ontosemiotic Approach [Malaspina & Font (2010)] ...but introducing an important variant. Instead of using a "basis" of processes defined a priori by the theoretical framework, we would use the "basis" that would be the result of a brainstorm performed by the participants in the project ...MC2 when each of them explained what they understood by "creative process".... As a consequence, the following aspects were revealed: a) When the members ...[participants in the project] aim at determining the criteria of design and assessment, they do not directly refer to the concept of CMT [Creative Mathematical Thinking], but they consider its decomposition into different dimensions, or processes, of mathematical activity, whose integration, through task design, [participants] think that would help to develop the CMT. b) There is a shared assumption that "the mathematical creative thinking will emerge from the interaction and integration" of these different dimensions or processes (p. 4–5).

On this line, in the master's degree final project -a document where the preservice teachers propose some changes to improve their own practice-, we could expect to find: 1) comments about creativity, since enhancing creativity is usually regarded as positive; and 2) in these comments, creativity would appear as a consequence of working other aspects that improve the instructional process.

Several studies on teachers' training suggest the reflection on the own practice as a key strategy to professional development and the improvement of instruction processes. On this line, the construct of didactic suitability of the Ontosemiotic Approach (Breda, Pino-Fan, & Font, 2017) has been used as a tool to structure the teachers' reflection in some teachers' training programs in Spain, Chile, Panama, Argentina and Ecuador (Breda, Font, & Lima, 2015).

The theory of didactic suitability originates from the need to have an instructional theory to help teachers to make decisions in designing, implementing and assessing their practice. Didactic suitability (Breda et al., 2017; Sullivan, Knott, & Yang, 2015) comprise six types of suitability. The epistemic suitability deals with the quality of the mathematics that are taught, and how the explained content is representative of the complexity of the mathematical object. The cognitive suitability is

about, on the one hand, the adequacy of students' previous knowledge for learning the intended content and, on the other hand, the relation between what students should learn a priori and what they have learnt indeed after the implementation. The mediational suitability has to do with the availability of time and material resources necessary in the teaching and learning process. The interactional suitability is the effectiveness of interactions (teacher-students or between students) to identify and solve conflicts of meaning and improve students' autonomy. The affective suitability refers to the students' involvement in the teaching and learning process. Finally, the ecological suitability is the adequacy of this process to the school's educational project, the curriculum and the social environment. In order to use these criteria as an assessment tool, some observable components and characteristics are associated with each criterion. They were used in the design of a practical rubric that can be found in Breda et al. (2017). As an example, we show the components and characteristics of epistemic suitability in Table 1.

Components	Characteristics
Errors	Practices considered mathematically incorrect are not observed.
Ambiguities	Ambiguities that could confuse students are not observed; definitions and procedures are clear and correctly expressed, and adapted to the target level of education; explanations, evidence and demonstrations are suitable for the target level of education, the use of metaphors is controlled, etc.
Diversity of processes	Relevant processes in mathematical activity (modelling, argumentation, problem solving, connections, etc.) are considered in the sequence of tasks.
Representation	The partial meanings (constituted of definitions, properties, procedures, etc.), are representative samples of the complexity of the mathematical notion chosen to be taught as part of the curriculum.  For one or more partial meanings, a representative sample of problems is provided.  The use of different modes of expression (verbal, graphic, symbolic...), treatments and conversations amongst students are part of one or more of the constituents of partial sense.

**Table 1: Components and characteristics of epistemic suitability (Breda et al., 2017, p. 1903).**

In our study, we distinguish which components of the different types of suitability preservice teachers relate to creativity in their comments, while they use the criteria to analyze their own practice.

## Context

The program of the master's degree in teaching in secondary school (specialization in Mathematics) includes a work placement in a secondary school divided into two periods. In the first period, that lasts two weeks, preservice teachers attend classes of their supervisors and know the group of students with which they will work later. The second period lasts six weeks, and the preservice teachers should implement a learning sequence that they have prepared. After the work placement, in the subject of

Innovation and research in Mathematics education, the didactic suitability criteria (Breda et al., 2017), with their components and characteristics, are introduced. Then, preservice teachers should use them in the analysis of the learning sequence that they implemented. The master's degree final project (MFP) includes this analysis and, based on it, the preservice teacher's proposal with some changes in the learning sequence that could help to improve the suitability of the teaching and learning process.

## Research questions and method

The aim of this study is to examine preservice teachers' ideas about promotion of students' creativity, while they analyze their own practice and justify some changes of the learning sequence to improve it, in their MFP. Preservice teachers do not receive any specific training in how to develop students' creativity during the master's degree. Our research questions are: 1) Do preservice teachers frequently include comments about the promotion of creativity in their MFP? 2) Which aspects of the teaching and learning process are related to the promotion of creativity in the preservice teachers' comments?

We considered the 198 MFP from the years between 2009-2010 and 2014-2015. First, we made a register with some information of each MFP (name of the preservice teacher, year, title of the learning sequence, level). We searched for explicit references to creativity or other words of the same word family (creative, creation, creator, create) in the MFP and made a second register with only those projects that include these comments (we used a reduced list of keywords in comparison with other studies, such as the one of Joklitschke, Rott and Schindler [2018]). Registered data of these MFP include the extracts with the explicit references to creativity, as shown in Table 2.

Then, we read the MFP with references to creativity and tried to find common patterns or characteristics in the comments in order to infer a classification of comments. Since the preservice teachers use the didactic suitability criteria to structure their analysis, we also used them to distinguish aspects that are associated with the promotion of creativity in the comments. It means that, in this first phase, we used the didactic suitability criteria as previous categorization to analyze the preservice teachers' discourse. Finally, in a second phase, we classified the comments into the different categories that we had formed inductively from the data.

For example, in the MFP of Fontalba (2014) we found two explicit references to creativity (shown in Table 2). In her analysis of the implemented learning sequence, the epistemic suitability is one of the worst valued. When she analyzes this suitability, she remarks that the learning sequence should include activities that enhance creativity (first extract in Table 2). Then, in the new proposal, she adds an activity in which the students have to create their own problems (second extract in Table 2). We consider that this comment is related to the diversity of processes (a component of the epistemic suitability) and, in particular, to the process of posing problems.

Title and year	Geometry in space. 2013 - 2014
Preservice teacher's name	F.D.
Level	3 <sup>rd</sup> course of Secondary School (14-15 years old)
Branch of mathematics	Geometry
References to creativity	Yes

Number of references	2
Extract	Diversity of processes. The mathematical quality of the learning sequence could be improved and one of the key components is the diversity of processes. The student should make, should learn through trial and error, manipulation, experimentation and exploration. There is an excess of algorithmic activities, to calculate and execute procedures, therefore activities that hold curiosity, creativity, imagination and discoveries should be included. (Fontalba, 2014, p. 4)
	Competence 4. Generating mathematical questions and posing problems. Clearly, this competence is developed since the goal of the contest is the creation and resolution of problems. (Fontalba, 2014, p. 11)
Comments	She refers to the development of creativity in the assessment of epistemic suitability, and she says that the diversity of processes should increase. Then, in the new proposal, there is a task in which the students have to create problems.

**Table 2: Example of the data of a MFP with some explicit references to creativity**

## Results

We found explicit references to creativity in 119 of the 198 MFP of the master's degree in teaching in secondary school from years between 2009-2010 and 2014-2015: in 2009-2010, 9 of 15 MFP include references to creativity; in 2010-2011, there are 16 out of 21 MFP; in 2011-2012, 20 out of 34; in 2012-2013, 14 out of 24; in 2013-2014, 25 out of 47; and in 2014-2015, 35 out of 57. In the MFP with references to creativity, we found different elements of the teaching and learning process associated with creativity. In the following lines, we describe the main categories that we distinguished and then we focus on one of them. The development of creativity is related to:

a) Tasks with notable processes (epistemic suitability). In some projects, the preservice teachers explain activities where students have to do some hypothesis, plan a resolution method, justify or put in practice other processes that are especially important while learning mathematics. In this category, we include those comments in which creativity is related to this type of activities. These preservice teachers expect to develop creativity using it to solve the activities. At the same time, epistemic suitability improves, since so does the diversity of processes, which is one of its components. 61 MFP include comments in this category.

b) The use of manipulatives and technology (mediational suitability). In this case, preservice teachers explain activities where students' creativity could be fostered by the use of computers and other material resources. Sometimes, preservice teachers do not refer to a mathematical creativity, but a plastic or artistic creativity that students practice in making a certain object that would be used in a mathematical activity later. 13 MFP include comments in this category.

c) The development of other skills that are useful in the current society (ecological suitability). In some MFP we found comments about a responsible use of creativity. Preservice teachers relate creativity to critical thinking or the development of the students' social competence. We associated these comments with the ecological suitability because they refer to some skills that are useful for living in society nowadays. 3 MFP include comments in this category.

d) Cooperative tasks (interactional suitability). In other MFP, preservice teachers explain activities in which cooperation between students plays a key role. Students' cooperation is necessary to solve the task and it would help to develop their creativity, while sharing their ideas in the resolution. 5 MFP include comments in this category.

e) The assessment procedures of the learning sequence (cognitive, interactional and affective suitability). In this category, we include the references to creativity that appear in the assessment criteria of the learning sequence or in the objectives of a certain activity that the preservice teacher proposes. Usually, in the corresponding MFP there are some changes in the assessment tools. For example, preservice teachers design new rubrics. They often oppose the traditional understanding of evaluation, proposing a competency based assessment and sharing the responsibility with the students through auto-evaluation and co-evaluation. These changes relate to several components: the learning, as a component of the cognitive suitability; the autonomy and the formative evaluation, as components of the interactional suitability; and attitudes and emotions, as components of the affective suitability. 18 MFP include comments in this category.

General comments. In some comments, we could not identify a clear connection between creativity and a particular element of the teaching and learning process, so we refer to them as general comments. In this category, there are references to the creative nature of the mathematical activity, references to the teachers' creativity when designing tasks to their students, and references to the role of creativity in the constructivism paradigm.

We observed that in 66 MFP there are more than one reference and, in some cases, several aspects of the learning sequence are related to the development of students' creativity. Most of the comments that are associated with a certain suitability criterion are in the category in which creativity is related to the diversity of processes. Therefore, we focused on this category, distinguishing different characteristics of the activities that the preservice teachers propose.

With regard to the comments in the first category, we found that in 14 MFP the development of students' creativity is associated with the resolution of problems, especially open-ended problems. Sometimes, creativity is specific to the phase of devising a plan to solve the problem. In 12 MFP, preservice teachers mention creativity when they ask the students to invent problems, think on significant contexts or create different representations. In 12 MFP, preservice teachers consider that the students' creativity can be fostered by working with real situations. 5 MFP include comments about developing creativity through project based learning. Five preservice teachers propose mathematical activities in the form of games that could enhance students' creativity. In the same category, there are some references to processes that preservice teachers relate to creativity: creation of arguments or justification (in 6 MFP), intra and interdisciplinary connections (in 5 MFP), creation of formulas and hypothesis (in 6 MFP), creation of mathematical models (in 5 MFP).

## Conclusions

Even when the preservice teachers do not receive a specific training in how to promote students' creativity during the master's degree, more than half of the MFP include references to creativity. First, we conclude that a significant number of preservice teachers in our sample implicitly consider that creativity can be developed in the mathematics lessons. There seems to be an implicit general agreement on the positive effect of the development of students' creativity on mathematics learning.

Second, preservice teachers' comments evidence that creativity is a complex topic and there are different ways to understand and promote it. We observe various elements or aspects of the teaching and learning process that are somehow related to the development of creativity in the preservice teachers' comments. Note that preservice teachers not only refer to mathematical creativity, their comments cover a wide view of creativity. Categories of the classification that we present here could change and evolve with the incorporation of new results from the analysis of the MFP of the following years of the master's degree. We conclude that preservice teachers consider that creativity is something that emerges from the interaction and integration of other aspects (especially different mathematical processes).

This study can contribute with results to other research on preservice teachers' education, showing evidence of the preservice teachers' perspective on creativity and its promotion in their learning sequences, when they do not receive any specific training in how to promote students' creativity. It could be interesting to observe how specific training in fostering students' creativity would affect the analysis that preservice teachers do in their MFP. We could also consider the possibility of using more keywords related to creativity to find comments in the MFP. As Joklitschke et al. (2018) explain, there are several conceptualizations of creativity and it is important to be aware that other words could be used to describe or conceptualize creativity. Then, we should consider other words that preservice teachers could use as synonyms of creativity. On the other hand, sometimes, the use of the word "creativity" does not seem to be relevant to the meaning of the whole comment or it is ambiguous (for instance, it is not clear whether it refers to teacher's or students' creativity). A possible solution would be revising the comments and rating their validity concerning their ambiguity.

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