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Ability of Spanish preservice teachers to differentiate between creative and reproductive activities in the classroom

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Abstract

Creativity is a key competency for the 21st century society and the development of certain scientific aspects related to creativity should constitute a priority in education. But to do so, teachers need to have the skills, confidence and pedagogical knowledge necessary. This paper investigates the ability of 190 Spanish future teachers to differentiate between creative and reproductive activities in the science classroom. Using the instrument prepared by Newton and Newton (2010) they were asked to rate a set of activities according to their capacity to develop scientific creativity. The results show that both the field of knowledge and the scientific topic influenced their responses, although they were able to differentiate between creative and reproductive incidents, with statistically significant differences in both topics studied.

Keywords: *Scientific creativity; classroom activities; preservice teachers.*

1. Introduction

The importance of creativity and creative thinking is recognized in the OECD reports and it has been included in the last PISA tests in 2022 (OECD, 2019). It is also considered a key competence for the 21st century (Henriksen et al., 2016). Consequently, there are references to creativity in the syllabus of many countries (Patston et al., 2021) and the recent Spanish Educational Law states that "[...] artistic creation, audiovisual communication, digital competence, the promotion of creativity and the scientific spirit will be worked on in all areas of Primary Education" (LOMLOE, 2020, p. 122873).

Thus, creativity should be present in all school disciplines and teachers will be responsible to training students with creative skills and competencies (Soh, 2017). However, the difficulty in defining creativity and the poor teacher training regarding creativity causes hesitation and doubts in its implementation (Mullet et al., 2016). Early childhood and primary teachers have stated that they feel unprepared to effectively promote student creativity in the classroom (Cheng, 2010). The study of Bereczki & Kárpáti (2018) show that inservice teachers, despite holding positive beliefs towards creativity, did not propose activities that foster creativity in their teaching practices. Recent studies with Spanish preservice teachers (Echegoyen & Martín-Ezpeleta, 2021; Martín-Ezpeleta et al., 2022) show that, despite their creative self-perception, their real creativity demonstrated in different academic works is not sufficient to promote creativity in the classroom.

With respect to science, there is an international consensus that it is intrinsically creative, and that the development of certain scientific aspects related to creativity should constitute a priority objective of education (Hetherington et al., 2020). There are different factors that can influence scientific creativity such as convergent and divergent thinking, general creativity and domain specific creativity, inquiry skills, or knowledge about science, among others. Newton and Newton (2010) proposed three types of activities to enhance scientific creativity in the classroom: a) through the speculative description of situations with tentative, hypothetical explanations and their possible alternatives; b) gathering knowledge and assessing ideas (such as proposing a method to gather reliable and descriptive information or an empirical test that allows contrasting a hypothesis); and c) applying scientific knowledge to solve a daily problem.

There are, however, different studies that point out to a lack of teacher preparation to adequately implement creativity in the science classroom (Ramnarain, 2018), despite its importance. Newton and Newton (2010) found difficulties in some primary education teachers to distinguish between creative and reproductive activities in the science classroom. Cruz et al. (2020) found that primary preservice teachers were not completely able to pose questions related to the primary education curricula for the development of scientific research activities. Another study (Izquierdo & Solaz-Portolés, 2022) shows that the inquiry skills of

Spanish primary preservice teachers are low. In this context, this study aims to evaluate the ability of Spanish preservice teachers to differentiate those science classroom activities able to promote creative thinking from others that were just reproductive activities were no creative thinking was involved.

2. Methodology

An *ex post facto* descriptive design was used to analyze the ability of Spanish preservice teachers to differentiate between creative and reproductive activities in the science classroom.

2.1. Participants

Participants were 190 students in their sophomore year of the Early Childhood Education Teaching and Primary Education Teaching degrees of a large Spanish university. This was a convenience sample pertaining to 6 different natural groups. 163 (85.8%) were female and 27 (14.2%) were male, wich corresponds to the population of study.

2.2. Instrument

The proposed classroom activities were selected from the instrument developed by Newton and Newton (2010). Originally this instrument was comprised of 36 short classroom incidents in three dissimilar science topics: "Earth, Space and Gravity"; "Electricity"; and "Plants and Animals". For the present study only 20 incidents related to the first two topics were used to not overload the participants. There were eight incidents favouring creative thought in science and eight incidents biased towards reproductive thought in science (four related with descriptive science and four with explanatory science). These 16 items corresponded to Field 1 (constructing notional scientific knowledge such as speculative descriptions of situations, tentative explanations, hypothesis, etc.) and Field 2 (constructing empirical ways of gathering knowledge and evaluating ideas). Four additional items were related to incidents in Field 3 (applying scientific knowledge to solve a practical problem). The various categories of items (descriptive-creative, descriptive-reproductive, explanatory-creative, explanatory-reproductive, problem solving-creative, problem solving-reproductive) appeared equally for each of the two topics. The degree of stimulation of creativity in each situation is asked to be rated using a 5-level Likert scale, where the lowest level means "no opportunity to develop scientific creativity" and the highest-level means "a very good or great opportunity to develop scientific creativity".

2.3. Data analysis

Descriptive statistical analysis was done using SPSS software version 28. Particularly mean and standard deviation was calculated for each of the variables. To check the normality of the distributions Kolmogorov-Smirnov test for one sample was used. Although not all of them presented normal distributions, the fact that mean and median values were similar and the analysis of Q-Q plots showed little deviations of normality (in the distribution tails) suggested the use of parametric tests. Thus, Students' t test for paired samples was used to compare the ability to differentiate between creative and reproductive activities. The significance level was set at .05.

3. Results

The mean scores (standard deviations in brackets) for each type of activity in topic 1 "Earth, Space and Gravity" and topic 2 "Electricity" are shown in Tables 1 and 2, respectively. They show that the creative activities in Fields 1 and 3 are generally scored higher than the reproductive ones. They have more difficulties in Field 2 (empirical ways of gathering knowledge) since the scores are similar between creative and reproductive activities in this field and even they give a higher score to the reproductive explanatory activity in field 2 in topic 1 (M = 3.64) than to the creative one (M = 3.58). It is worth pointing out that the items in fields 2 and 3 tended to obtain higher scores than those in field 1, independently of their nature. This indicates that these preservice teachers consider that practical and problem-solving activities have a higher capacity to foster creative thinking in science than the non-practical ones.

Table 1. Main scores awarded to the incidents in the different fields for topic 1: "Earth, Space and Gravity". (The higher the score, the greater the perceived opportunity for creativity).

	Reproductive activities			**Creative activities**		
Field	Descript	Explanat	Problem_solv	Descript	Explanat	Problem_solv
1	3.11 (1.13)	2.57 (1.07)		3.64 (.94)	3.90 (.91)	
2	3.69 (.97)	3.64 (.99)		4.23 (.87)	3.58 (.93)	
3			3.56 (1.08)			3.83 (.96)

Comparing our results to those obtained by Newton and Newton (2010) with in-service teachers, it is apparent that the difference in the scores obtained by creative and reproductive activities is much lower in the case of preservice teachers. The mean scores also tend to be higher in the case of preservice teachers: in the study of Newton and Newton (2010), the highest score of 3.04 was awarded to descriptive creative incidents in field 1 in the topic "Electricity", while in our study there were mean values above 4 points in four cases, one in the topic "Earth, space and gravity" and three in the topic "Electricity". In this last topic a mean score above 4 was awarded even to descriptive reproductive activities in field 2. This could be due to the fact that the sample in this study is composed of preservice teachers at their sophomore year, so they might not have yet assimilated what it means to be "creative in a science classroom".

Table 2. Main scores awarded to the incidents in the different fields for topic 2: "Electricity". (The higher the score, the greater the perceived opportunity for creativity).

	Reproductive activities			Creative activities		
Field	Descript	Explanat	Problem_solv	Descript	Explanat	Problem_solv
1	2.71 (1.06)	2.82 (1.11)		3.74 (.94)	3.65 (.84)	
2	4.27 (.94)	3.95 (1.06)		4.27 (.70)	3.93 (.87)	
3			3.57 (1.11)			4.10 (0.87)

A more general view of the results can be found in Table 3, where the scores of all creative and reproductive activities are grouped by topic. It is apparent that in all cases, the scores awarded to creative incidents are higher than those awarded to reproductive incidents for both topics. To assess if those differences were statistically significant, Students' t test for paired samples was carried out. The results (see Table 3) showed that it was statistically significant in all cases, with a large size effect in both of them as considered by Cohen (1988) for behavioral sciences.

Table 3. Descriptive statistics and results of the t test for paired samples for the scores awarded to creative and reproductive incidents in both topics.

	Min	Max	Mean	SD	t	p	d
Creat topic 1	2.67	5.00	3.79	.52	12.202	<.001	1.05
Repr topic 1	1.75	5.00	3.25	.68			
Creat topic 2	2.60	5.00	3.94	.51	8.587	<.001	.78
Repr topic 2	1.20	5.00	3.47	.75			

It is also worth pointing out that this group of preservice teachers gave higher scores for both reproductive and creative activities in topic 2 than in topic 1. This can be due to the fact that, as Jarvis and Pell (2004) stated, most primary teachers (and also preservice teachers) are not science specialists and their knowledge in the different topics may differ, which will make more difficult to assess the ability to promote creativity in one topic than the other. It is also worth noting that some students gave high scores (even the maximum score of 5 points) to reproductive activities in both topics, and that the mean score of reproductive activities was also high, which might indicate that they do not understand what creativity in science is and how to foster it.

4. Conclusions

The results of this study show that Spanish preservice teachers are in general capable of differentiate between reproductive and creative activities in the science classroom. However, the results are not completely satisfactory. The set of items considered creative obtained similar results to those obtained in previous studies (Newton & Newton, 2010), so there was a clear recognition of those activities as opportunities to develop creativity in students. On the other hand, most of the participants also valued reproductive-type activities as good opportunities to develop the creativity of the students, contrary to what was expected. This could be related to the type of training received at the faculty of teacher training, with little disciplinary specialization (in this case, in science) and a lot of general and transversal didactic training, being both parts of the pedagogical content knowledge (Gudmundsdottir & Shulman, 1987).

Didactic training received by these preservice teachers is generally based on preparing activities whose value seems to be given to the procedure and materials (what is done and how), but not always to its content (what must be learned). Therefore, when they are presented with activities involving manipulation or involving innovative materials, they tend to think that there is also an opportunity to develop creativity even if those activities are of a reproductive type.

Thus, there is a need to improve the training of teachers in the development of creativity in the scientific field for which a supportive learning environment encouraging curiosity, inquiry and innovation is key. Teachers need to consider the learning objectives, level of student engagement and autonomy, complexity, and assessment method, which focus is different in creative and reproductive activities. By doing so, they can design activities that promote creativity and critical thinking, and help students to apply their knowledge in new and innovative ways.

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