



## THE TURNING POINT: SCIENTIFIC CREATIVITY ASSESSMENT AND ITS RELATIONSHIP WITH OTHER CREATIVE DOMAINS IN FIRST YEAR SECONDARY STUDENTS

I. Pont-Niclòs<sup>1</sup>, A. Martín-Ezpeleta<sup>2</sup>, Y. Echevoyen-Sanz\*<sup>1</sup>

<sup>1</sup>Department of Science Teaching, Faculty of Teacher Training, University of Valencia, Valencia, Spain

<sup>2</sup>Department of Language and Literature Teaching, Faculty of Teacher Training, University of Valencia, Valencia, Spain

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### ABSTRACT

Research on creativity, as well as its application to the education field and its assessment at the different educational stages, have been of increasing interest over the past decades in different countries. In this context, this study aims to evaluate performance in scientific creativity and its relationship with other creativity domains (linguistic and general creativity) of Spanish first-year secondary students. This is a key moment both from the point of view of the change in educational level and a critical age in cognitive developments associated with creativity. The research was carried out using a quantitative, descriptive, cross-sectional design. Data was collected using previously validated tests. Results revealed a moderate-to-low performance for the scientific domain, as well as for the linguistic one and for general creativity. In addition, positive correlations have been found between all the studied domains of creativity. Nevertheless, this correlation was stronger between both scientific creativity dimensions (daily and specific). This research shows the scarce creative competence of students at the early stage of secondary education and gives evidence about the multicomponent nature of creativity. The need for the inclusion of creative teaching strategies at the secondary education level via transdisciplinary approaches is discussed.

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Keywords: creativity domains; scientific creativity; secondary education

### INTRODUCTION

Among the 21st-century skills (those needed to prepare students to succeed in their careers during the information age) are a solid education in science and the need for creativity and innovation (Kennedy & Sundberg, 2020). In fact, creativity has recently been put at the forefront of the educational research agenda. Therefore, an increasing number of countries have embedded this topic in their educational policies, including several countries that form part of the European Union (Austria, Belgium, Czech Republic, France, Portugal, Spain, among others), as well

as Australia, China, England, the United States and Taiwan, for instance (Pillana, 2019; Patston et al., 2021).

Education fosters creativity by means of reinforcing acquired knowledge, cognitive skills, willingness to new experiences, and collaboration. Moreover, creativity has been associated with problem-solving, communication and metacognitive skills, which may enable not only academic and professional achievements, but also it may meet student's needs in their daily life (Batey & Furnham, 2006). Therefore, creativity has a key role in education, which has been grounded by the development of regulatory policies and assessment methods.

\*Correspondence Address

E-mail: yolanda.echegoyen@uv.es

Research on creativity and education may be divided into four large categories. The first one is focused on personality traits that may hinder or foster creativity, such as conformism or resilience. The second one falls into the cognitive area and addresses those factors affecting the creative process, for instance, intelligence or problem-solving abilities. The third one puts emphasis not on students, but on the educational system. Therefore, it tackles the analysis of curricula and initiatives to develop creativity. The last approach falls into a much more sociopsychological area, investigating the relationship between experience, behavior, environment, and students' creativity.

Since all of these categories explore the potential links between creativity and specific concerns, scholars resort to several techniques in order to assess students' creativity. This includes methods ranging from self-report questionnaires (Jonason et al., 2017), divergent thinking tests (Runco et al., 2016), and personality tests (Puryear et al., 2017), to more specific assessments centered on concrete domains by means of different settings (Lemons, 2011; Said-Metwaly et al., 2017). Given the substantial accumulation of assessment approaches, researchers are often involved in controversial debates. The key concern nowadays deals with the lack of an established conceptual and methodological framework, which leads to a vast quantity of scattered literature analyzing some creative processes and phenomena in an isolated manner.

To overcome this limitation, reviews have been published compiling creativity assessments in a large variety of settings (Snyder et al., 2019; Karwowski et al., 2019; Acar & Runco, 2019). Furthermore, there are other reviews pointing to the imperative need of achieving accuracy, homogenization, and transparency of the reported creativity results, which may lead to the refinement of research and assessment methods in creativity (Barbot et al., 2019). Those define a series of guidelines, such as providing transparent evidence of data selection and analysis, properly applying statistical tests according to the given sample, and interpreting results in terms of a well-defined creativity construct (Barbot & Said-Metwaly, 2021). Regarding the latter guideline, there is still little consensus in the field about which creativity construct to follow.

In this context, the existence of domains and their role in creativity performance have been hot topics of discussion since the early stages of formal creativity research. Aiming to get insight into the domain specificity of creativity, Baer and

Kaufman (2005) proposed the Amusement Park Theoretical (APT) model, which includes both general and domain elements. The structure of the model is hierarchically established using four levels: initial requirements, such as intelligence or motivation; thematic areas, regarding different knowledge disciplines; domains, related to specific areas within those disciplines; and microdomains, corresponding to concrete tasks within those domains. Although the APT model is considered to present some limitations, there is a widespread consensus on the multicomponent nature of the creativity construct (Barbot et al., 2019).

In the literature, there are different studies focusing on a certain creativity domain. Some embrace a linguistic approach, such as metaphor generation, since it is considered to be an explicit manifestation of creative thinking (Bergs, 2019). Other domains, such as art, mathematics or music, are also analyzed in several studies (Erbaş & Bas, 2015; Mansour, 2018; Kladder & Lee, 2019).

Regarding scientific creativity, it has been addressed by means of specific scientific productions or problem-solving patterns (Chen et al., 2016; de Vries & Lubart, 2019). In fact, a comprehensive meta-analysis of empirical studies examining the domains of creativity supports the idea of the existence of a mathematical/scientific domain that is consistently distinct from other domains of creativity (Julmi & Scherm, 2016). The existence of a particular scientific domain in creativity is not surprising, since the role of creativity in the processes of generation of knowledge in science is evident, with many similarities between the creative process and the scientific method (Garcés, 2018). Science can foster creativity and creativity should be an essential component of science in school (Antink-Meyer & Lederman, 2013). Ramdani et al. (2022) point to creativity and curiosity as important variables to support the performance of outstanding science teachers. The influence of aspects such as motivation (Xue et al., 2018), attitudes (Nursiwan & Hanri, 2023), science process skills (Fadlan et al., 2019), and emotions (Feist, 2015) in scientific creativity has been studied. There are some studies showing a positive correlation between scientific and mathematical creativities (Huang et al., 2017). However, to the best of our knowledge, no study has previously addressed the relationship between the scientific and linguistic domains of creativity.

In recent years, the comparison among different creativity domains has attracted a lot of interest, and even more so, their relationship with a general creativity construct, which commonly

is wrongly associated exclusively with divergent thinking tests (Baer, 2015). However, those approaches are thought to lead to contradictory results (Kaufman et al., 2017). Therefore, researchers sought to embrace a much more holistic approach, assessing multiple domains of creativity, by means of a more accurate analysis design (Long et al., 2022), as is performed in this research.

To fill this gap and to gain more insight into the Spanish secondary education context, this study aims to assess a key area of creativity, as is the scientific domain, and study its relationship with other creativity domains in first-year secondary students. This is a turning point since it corresponds to the change between primary education and secondary education (where educational methodologies usually change with the introduction of scientific disciplines and the progressive abandonment of project-based learning). This is also a key stage in the development of creativity, since there is a discontinuity between creative potential in childhood and adolescence, with each stage associated with distinct developmental conditions and pathways, as well as biological and psychosocial changes. This has been confirmed by neuroscientific evidence of the decrease of gray matter during adolescence (Raznahan et al., 2010) leading to the observed creative cognition slumps and the decrease of divergent thinking in this developmental stage (Lau & Cheung, 2010). A recent meta-analysis (Said-Metwaly et al., 2021) positions this slump in seventh grade, in ages 12-13, the target population of this study.

In this context, the main objective of the present study is to assess the scientific creativity of first-year secondary students and explore its correlation with other creative domains (linguistic creativity and general creativity), as this has not been done before. The research questions were as follows: a) What is the scientific creativity level of first-year secondary students? b) What is their performance in linguistic creativity and general creativity? d) Are there differences in terms of gender? d) Is there a correlation between the scientific and linguistic domains of creativity? And between those domains and general creativity?

## METHODS

This study utilized a quantitative, descriptive, cross-sectional research design. Participants were 226 first-year secondary students from three different Spanish high schools, from both rural and urban areas located in eastern Spain. There

was gender homogeneity among the participants with 47% male students and 53% female students. The age of participants ranged from 11 to 14 years old, with an average age of 12 years old, which is the typical age of students at this level in Spain. As mentioned above, this is a key stage in the development of creativity, coinciding with the discontinuity between creative potential in childhood and adolescence.

Data was collected during the 2022-2023 academic year (in paper-based questionnaires) in 50 minutes sessions for every class group. Prior to the sessions, school management teams, legal guardians, and participants were informed about the treatment of the data and the scope of the research. Three previously reported and validated instruments were used to assess scientific creativity, linguistic creativity, and general creativity.

a) The scientific creativity dimension was assessed using a problem-setting up questionnaire developed by Hu et al. (2010), which is based on the Torrance model of creativity, and is described by the authors as robust and reliable (with inter-rater reliabilities between .69 and .85). Therefore, problem finding creativity was assessed in terms of fluency (how many ideas), flexibility (variety of fields corresponding to those ideas) and originality (statistical frequency of those ideas at the analyzed sample). This instrument includes two items. The first one aimed to assess the daily scientific creativity (DSC) consists of an open instruction, in which students are asked to write as many and different questions as they can related to science and based on their everyday life experiences. The second item aimed to assess the specific scientific creativity (SSC) corresponds to a closed instruction. Participants ought to create scientific questions associated with the image of an astronaut standing on the moon, and, therefore, this item captures more specific scientific knowledge, which yields the formulation of creative questions. Items were presented to students as PowerPoint slides and the time to generate questions was limited to 8 minutes per item. As mentioned above, the scoring was three-folded: the fluency score is associated with the number of valid questions generated, the flexibility score corresponds to the fields in which those are categorized, and the originality score is related to the statistical appearance frequency of a given question. DSC and SSC scores were calculated as the sum of these three values.

The different categories for each questionnaire are presented in Tables 1 and 2.

**Table 1.** Codification of Flexibility Categories Corresponding to DSC

Code	Field of Knowledge
ANT	Anthropology (evolution)
AST	Astronomy
BIO	Biology (plants, animals, genetics)
SCIE	Science Spirituality and Feelings
CON	Constructions and Transport
COV	COVID
PHY	Physics
GEO	Geology (meteorology, earth composition)
HUM	Human Body, Health
PRO	Products properties and their usage
CHEM	Chemistry (materials properties and reactions)
TEC	Technology

As can be seen, there were 12 different categories for daily scientific creativity and 7 different categories for specific scientific creativity.

**Table 2.** Codification of Flexibility Categories Corresponding to SSC

Code	Field of Knowledge
AST	Astronomy in general
EXT	Extraterrestrial life
PHY	Physics (gravity, space traveling)
MOO	Moon's Composition and Meteorology
LIG	Sunlight, darkness, and looking at the moon
TEC	Technology and Communications
LIF	Daily life of astronauts on the moon

b) The linguistic creativity dimension was assessed in terms of a metaphor generation task, based on the work of Kasirer and Mashal (2018), which distinguishes between novel creative metaphors from conventional ones. The instrument includes 10 items. Whereas each of them corresponds to an emotion, half of them were presented in order to yield a metaphor (e.g., love is...) and the other half were presented aiming to promote an analogy formulation (e.g., sadness is like...). Students ought to generate a novel figurative expression, avoiding the use of synonyms or commonly used metaphors. The time provided to answer was limited to 8 minutes in total. The scores given were 1, 2 or 3 points, for literal responses, conventional figurative expressions, and novel metaphors, respectively. The linguistic creativity was calculated as the sum of all the obtained points. Two judges coded the data independently, with an agreement rate of 90%. Any case of disagreement was discussed by both coders. c) General creativity was addressed using a

previously validated questionnaire widely used in the Spanish educational context, which is known as CREA. In this case, students ought to generate as many questions as they can pertaining to what is happening at an image. Hence, several cognitive schemes are tapped into, arising from the interaction between the new mental representation of the image, and their already existent mental network of representations. The time established for the test is 4 minutes. This test has been found to have both predictive and concurrent validity (as measured in concurrence with the Guilford test of creativity) (Corbalán et al., 2015). Prior to assigning the corresponding scores, out-of-context questions or repetitive questions were invalidated. Each simple question is awarded 1 point, whereas double or triple questions (which reflect two or three different phenomena or actions) are ranked as 2 and 3 points, respectively. The percentile index is extracted afterward from the CREA Manual (Corbalán et al., 2015) for a Spanish sample.

The statistical analysis of the compiled data was performed using SPSS software version 26. Firstly, the mean and standard deviation for each of the studied dimensions of creativity was calculated. To get insight into the normality of the data, the Kolmogorov-Smirnov test was carried out. Since all variables presented non-normal distributions, differences according to gender were explored using the Mann-Whitney U test. The effect size was calculated using the formula described by Field (2018) for non-parametric samples. The magnitude of the effect size was evaluated according to Cohen's classification for behavioral sciences (1988), being null if  $0 \leq |g| \leq .1$ ; low  $.1 < |g| \leq .29$ ; medium  $.30 < |g| \leq .49$  and large if  $.5 \leq |g|$ . Finally, the correlation

among the studied creativity dimensions and the general creativity was evaluated by means of the Pearson's correlation coefficient. In all cases the significance level was .05.

## RESULTS AND DISCUSSION

The main aim of this study was to assess the scientific creativity of students at the beginning of secondary education. The results associated with both scientific dimensions of creativity (DSC and SSC) are shown in Table 3. This table also includes the scores of the three evaluated properties (fluency, flexibility, and originality).

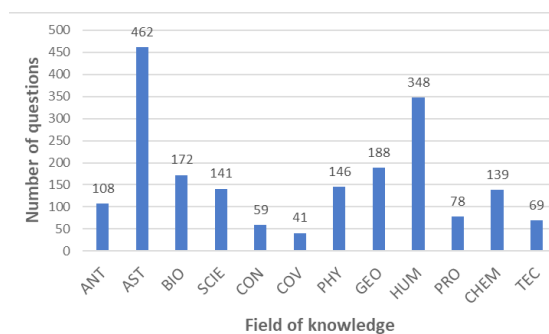
**Table 3.** Descriptive Statistics for both Scientific Dimensions of Creativity

Creativity dimension		Mean	SD
DSC	Fluency	8.63	4.78
	Flexibility	4.57	1.87
	Originality	0.75	1.15
	Total	13.96	6.70
SSC	Fluency	9.20	4.67
	Flexibility	4.26	1.30
	Originality	0.31	0.67
	Total	13.73	5.91

As can be observed in Table 3, fluency scored around 9 for both studied dimensions, meaning each student have formulated 9 questions approximately. Indeed, it has been detected that students tend to formulate many similar questions in their questionnaire answers. As an example, in the case of the daily-scientific dimension, students lay down a multitude of queries about the Universe and astronomy, such as: "Why does the sun rise in the morning and why does the moon come out at night?"; "Why is the Universe infinite?"; "Is there extraterrestrial life?". On the other hand, for the specific-scientific dimension, questions formulated by students tend to be rela-

ted to the composition of the moon, its morphology, and the possible existence of air, oxygen, and an atmosphere, e.g.: "Is there oxygen on the moon?"; "Why is the flag waving if there is no air on the moon?"; "Why are there craters on the moon?"; "Why is the moon grey?".

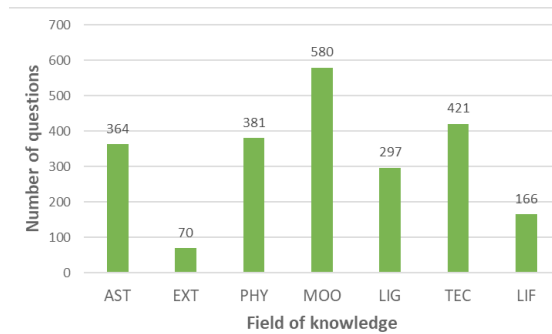
Regarding flexibility, its score is roughly 4 for both dimensions of scientific creativity, meaning students use approximately 4 different knowledge fields to formulate an average of 9 questions. Figures 1 and 2 represent the number of questions per category for DSC and SSC, respectively.



**Figure 1.** Number of Questions Formulated by Students, Corresponding to Each Field of Knowledge for DSC

It can be observed that the fields that show a higher count are “Astronomy” and “Human body/Health” for DSC and “Moon’s composi-

tion and Meteorology” and “Technology and Communications” for SSC.



**Figure 2.** Number of Questions Formulated by Students, Corresponding to Each Field of Knowledge for SSC

Concerning the originality score, it hardly reaches 1 for both investigated scientific dimensions of creativity. In other words, barely one of the averaged 9 questions formulated by students was unusual or unique (with a percentage of appearance frequency lower than 5%). DSC original queries were very varied, for instance: “How is paint made?”; “What is the operating mechanism of a microwave?”; “Why do we have to age?”; “Why do we feel pain?”. Note that almost all the original questions pertain to daily actions or phenomena related to everyday life. In the case of SSC, some original questions formulated by students were as follows: “Why is there a hidden face of the moon?”; “If we were to reach a gaseous planet, would we fall into its nucleus?”; “Are earthquakes possible on the moon?”; “Do diseases exist in

space?”. These results are similar to those reported by Hu et al. (2010). Particularly, the ability to come up with new ideas (originality) and the overall scientific creativity performance tends to be limited. Students generally use the same fields of knowledge to formulate questions (low flexibility), such as Astronomy and Health (DSC), and Technology and Physics (SSC). Moreover, queries are often non-related to students’ experiences and inquietudes, and tend to reflect a de-contextualized conception of science as an abstract and complex discipline.

On the other hand, the results corresponding to the linguistic dimension of creativity with the different metaphor categories are shown in Table 4.

**Table 4.** Descriptive Statistics for the Linguistic Dimension of Creativity

	Creativity domain	Mean	SD
Linguistic	Novel metaphor	0.95	1.62
	Conv. metaphor	1.42	1.43
	Literal response	5.53	2.99
	Invalid response	3.04	2.60
	Total	11.23	5.26

As can be observed, “novel metaphors” is the category with fewer responses. Indeed, barely one of each student’s responses falls into this category. As for conventional metaphors, students come up with a mean of one to two of them in their responses. However, the literal answers are those prevailing over all the other categories, since students tend to give examples of how they feel instead of creating novel metaphors or thinking about preexisting ones. Within this category, typical teenage feelings have been identified, such as

friendship, loneliness, or body-image insecurities. Additionally, comparisons regarding academic issues are recurrent, as well as analogies with video games, football teams and players. Finally, a large amount of students’ responses were invalid, since they were blank or reflected an erroneous concept.

Analogously to what happened for scientific creativity, linguistic creativity results indicate a moderate to low performance. This latter observation is similar to the one reported by Kasirer

and Mashal (2018), and their capacity to generate novel metaphors is lower than the one obtained by Kasirer and Mashal (2016) with typically developed Hebrew-speaking adolescents. Specifically, students tend to generate analogies closer to their experiences, rather than create novel and unique metaphors. It is important to consider that at this educational stage, students are not able to fully understand the concept of a metaphor, and therefore, they commonly approach this creativity task using already existing mental representations, regarding their own experiences and observations (Carriedo et al., 2016). In addition, those participants that generate novel metaphors usually use similar stylistic devices, such as personification or apostrophe, and comparisons with some meteorological phenomena.

Finally, in the CREA test for the assessment of general creativity students formulated an average of approximately 11 queries about the image shown, and the number of extra questions (double or triple) was scarce. They obtained a total mean value of  $11.2 \pm 5.26$ . Results were

much lower than those obtained by Donadel et al. (2021) for an adolescent Argentinian sample, although in their case there were also older (up to 16 years old) students. Most asked questions were related to the feelings of the characters in the image, their ages, their appearance, their clothing, and their occupations, as well as the location of the image. Regarding the percentile, it was 39%, below the median value, meaning that the general creativity was moderate-to-low. This reflects that students at this educational stage possess a scarce level of creativity, being below the median percentile. Note that the test used in this study is based on a question formulation process throughout the visualization of an image. Therefore, this test reflects the openness and versatility of the cognitive schemes of students, which results in the reorganization and interconnection of different mental representations. Authors of the test suggest that this behavior may result in a potential ability to develop creative competences (Corbalán et al., 2015).

**Table 5.** Descriptive Statistics for the Studied Dimensions of Creativity According to Gender ( $N_{\text{male}}=107$ ;  $N_{\text{female}}=119$ ).

Dimension	Gender	Min	Max	Mean	SD	z	p	g
DSC	M	2	33	13.07	6.28	1.748	0.082	-
	F	3	37	14.75	6.98			
SSC	M	0	28	12.28	5.81	3.393	<.001***	.226
	F	4	31	15.03	5.73			
Linguistic	M	0	29	10.27	5.45	3.280	.001***	.218
	F	1	29	12.10	4.95			
General	M	1	97	30.60	27.83	4.439	<.001***	.295
	F	1	98	47.56	28.91			

\*\*\* There are statistically significant differences at the .001 level.

Once a general overview of the creativity performance was obtained, the possible existence of gender differences in all the creativity dimensions was investigated, since not many studies address gender performance in specific creativity dimensions. Table 5 shows data according to gender (the data for general creativity is given as the percentile index).

As can be observed, scores corresponding to female participants are higher in all studied creativity dimensions. Particularly those associated to SSC and general creativity, both of which are remarkably higher. As all the dimensions presented non-normal distributions, the Mann-Whitney U test was applied to gain an insight into the existence of statistically significant differences. The results indicate that all the evaluated dimensions of creativity display statistical-

ly significant differences between genders, with the exception of DSC. The size effect was low for SSC and linguistic creativity, and medium for general creativity. These findings are in concordance with those reported for prior studies in general creativity (Nakano et al., 2021). Generally, females are regarded as creative beings, especially in arts and performance domains (Kaufman, 2006; Elisondo, et al., 2022; Pont-Niclòs et al., 2022), and not particularly in scientific or technical domains. However, these results show that gender stereotypes are not always accurate.

Finally, to explore the possible existence of any correlation between scientific creativity and the other studied dimensions of creativity, Pearson's correlation coefficients were calculated (see Table 6). As can be observed, there is a positive and significant correlation in all cases.

This means that those students performing in a particular manner at a concrete dimension of creativity display an analogous behavior at the other dimensions. It is worth noting that there is a higher correlation between both scientific dimen-

sions of creativity (DSC and SSC) than between those two found in the linguistic dimension. The highest correlation with the general measurement of creativity is with SSC.

**Table 6.** Pearson's Correlation Coefficient between the Studied Creativity Dimensions

	<b>DSC</b>	<b>SSC</b>	<b>Ling.</b>	<b>General</b>
DSC	1	.66***	.49***	.54***
SSC		1	.49***	.64***
Ling.			1	.45***
General				1

\*\*\* There are significant correlations at the .001 level

Since the correlation between scientific creativity with other creative dimensions had not been previously studied, only with mathematical creativity (Huang et al., 2017), this fact could be misinterpreted as a point corroborating the general construct of creativity, whose validation has a leading role at the debates within this field (Baer, 2015; Snyder et al., 2019). On one hand, students who show a concrete creativity performance at one dimension, typically show the same efficiency at others. On the other hand, it must be taken into account that the strongest correlation has been detected between both studied scientific creativity dimensions (DSC and SSC), rather than those and the linguistic. Moreover, results point out that the assessment procedure influences students' performance, since the highest correlation was found between SSC and the general creativity measurement, and both tests are based on the idea of formulating questions on what is happening in an image. Regarding this fact, several studies have shown that different modes of thinking involved in different types of creative work are accompanied by different patterns when it comes to brain activity (Kleibeuker et al., 2013).

At this point, it is important to consider different approaches that can contribute to the development of creativity in science. Although domain knowledge is important in scientific creativity (Sun et al., 2020), teaching styles must encourage students to come up with new and unusual ideas in a respectful environment. This is something pedagogically irrefutable, but not the norm in the Spanish educational system.

On the other hand, different approaches such as problem or project-based learning seem a good starting point since they are believed to promote many processes related to creative thinking (Anazifa & Djukri, 2017; Rasul et al., 2018; Sumarmi & Kadarwati, 2020). This type of methodology is perfectly aligned with the STSE (Scien-

ce-Technology-Society-Environment) approach. Also, establishing rewards and promoting self-fulfillment can be used to enhance students' motivation, particularly the intrinsic one (Begeth & Kaufman, 2014), as well as the use of gamification strategies in science classes (Funa et al., 2021). Moreover, teachers should facilitate creative examples, which students will be able to emulate. Indeed, creativity emulation is an emergent research area (Cotter et al., 2022) focused on how the creativity of students can be fostered via teachers' recreation of creativity performance.

Finally, several studies have assessed the creativity demonstrated by preservice primary education and chemistry teachers (Echeгойen & Martín-Ezpeleta, 2021; Martín-Ezpeleta et al., 2022; Apriwanda & Hanri, 2022) with discouraging results. Connected to the above, they should promote a reflection on the process, in the form of a metacognitive reflection. Metacognition processes play a key role in creativity capabilities since they deal with the self-efficacy concept and the proper contextualization of creative actions. Therefore, teachers should incorporate actions at their lessons including different metacognition mechanisms in order to promote the development of creativity (Kaufman & Beghetto, 2013).

## CONCLUSION

The main aim of this work was to assess the scientific creativity of first-year secondary students and evaluate their correlation with different creative domains. The results obtained pointed out the scarce creative competence of students at the early stage of secondary education in all three dimensions studied. Although there were correlations between all creative dimensions assessed, those were higher between both kinds of scientific creativity (daily and specific) than between scientific creativity and other creative domains. This points out the multicomponent nature of the creativity construct. In addition, gender diffe-



rences in creativity performance have been obtained for all creative dimensions, with female students demonstrating higher creativity scores in all cases. Nevertheless, first, some limitations need to be pointed out. Only one grade of secondary education has been assessed and the instruments used, although validated, could have their limitations. Future studies will focus on larger and even more delocalized samples. It would also be very interesting to corroborate this low level of creativity in science with longitudinal studies of all levels of secondary education. In spite of these limitations, our results lead us to conclude the importance of rethinking the development of creativity in the educational system. As discussed in the previous section, there should be a reorientation of the curricula and teaching methodologies in science lessons, as well as in other subjects. Certainly, different teaching concerns such as the above-mentioned problem-solving, critical, and divergent thinking are transversal key points in education. Accordingly, it is essential to raise awareness among educational professionals about these considerations, as well as to design didactic resources within each subject, which will enable the fostering of creativity as a collective educational aim. Although some of those factors have been considered recently in the educational agenda, they are not always present in secondary education classrooms in Spain and, particularly, not in science lessons. The present research shows that students' mediocre results should lead to a response in the form of innovative educational designs giving creativity the space it deserves.

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