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Leidy Dahiana Rios-Atehortua , [Tarcilo Torres-Valois](#) ^{*} , [Joan-Josep Solaz-Portoles](#) , [Vicente Sanjosé-López](#)

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Article

Pre-Service Science Teachers' Conceptions about Creativity at School: A Study in the Hispanic Context

Leidy Dahiana Rios-Atehortua ¹, Tarcilo Torres-Valois ^{2,*}, Joan Josep Solaz-Portolés ³
and Vicente Sanjosé ⁴

¹ Facultad de Educación, Universidad de Antioquia, leidy.rios@udea.edu.co

² Facultad de Educación, Universidad de Antioquia

³ Science Education and CDC-Profesores Research Group, Universitat de València, joan.solaz@uv.es

⁴ Science Education and CDC-Profesores Research Group, Universitat de València, vicente.sanjose@uv.es

* Correspondence: Tarcilo Torres; tarcilo.torres@udea.edu.co

Abstract: The present study examines the views of prospective science teachers in Colombia on creativity, employing a mixed-method approach that combines qualitative and quantitative techniques. This approach adapted and used an instrument previously developed by Diakidoy and Kanari [1] to explore student teachers' beliefs about creativity. The sample consisted of 152 science education students from two leading Colombian universities in representative cities. The findings align with previous international studies involving both practicing and trainee professionals, although subtle differences, likely due to cultural variations in the university settings, were observed. It emerged that future science teachers predominantly view creativity as an innate ability present in everyone and capable of development. Additionally, the study underscores the role of the classroom environment in fostering creativity, noting that effective creative expression also requires certain level of prior knowledge.

Keywords: creativity; science education; science teachers; pre-service teachers' beliefs

1. Introduction

Creativity, particularly within the realm of sciences, has garnered increasing interest in the educational community. UNESCO [2] has emphasized the importance of creativity as a fundamental competency for citizens of today and the future. The PISA program [3] included a specific assessment of creative thinking, manifested in "creative expression" and "knowledge creation and creative problem-solving." Education in creativity presents a new challenge to teachers, whose traditional didactic preparation has not encompassed this skill. Contrarily, school science is often perceived as a closed set of knowledge that should not be questioned by non-experts [4], and thus, divergent, and critical thinking, and student creativity are not commonly seen as didactic objectives [5].

Berrios et al. [6] demonstrated that there is a significantly positive and predictive relationship between teachers' beliefs about students' abilities and the creative performance of those students. Therefore, ensuring that teachers' beliefs are appropriate and aligned with researchers' knowledge is crucial, but change involves a new school culture [7], greater institutional support [8], and more resources and training for teachers [9].

Consequently, it is essential to reconsider teacher training to effectively promote creativity among students. This effort should consider teachers' own views on creativity, including their concepts, beliefs, and classroom practices, using these as a foundation for integrating effective teaching strategies into teacher training programmes designed to nurture scientific creativity in society.

1.1. Studies on Teachers' Beliefs about Creativity

Teachers' beliefs are personal, loosely structured knowledge highly influenced by everyday experiences, and they significantly impact teaching practices. These beliefs represent subjective

knowledge that guides teachers' actions and decisions in their classrooms [10]. Due to the relationship between teacher thought and action concerning creativity [11], various studies on teachers' beliefs about school creativity have been conducted in different countries and cultures: Cyprus [1], the United Kingdom [12,13]; USA [14,15]; Greece [16], Finland [17]; Hong Kong [18], South Korea [15,19]), Taiwan [11], and China [20], among others.

These studies show significant convergence, for example, in that teachers highly value creativity and associate it with novel outcomes, although not necessarily correct or appropriate. For example, Huang et al. [20] reveals that many teachers' conceptions of creativity are limited or vague. Teachers believe that they are ill-prepared to address creativity in their classrooms [21], that every person has educable creative potential, and that school creativity is associated with the arts rather than other disciplines, such as science [14]. Teachers' beliefs and actions show specific contradictions; on one hand, there is a positive predisposition towards developing creativity and the importance of divergent thinking and problem-solving is accepted, but on the other hand, the importance of convergent thinking, problem definition, and the integration of artistic and scientific realms in school activities is overlooked [11]. The results of Bereczki and Karpati [22] literature review suggest that teachers hold beliefs that hinder the development of creativity in schools. The review also highlighted the recurrent incongruence between teachers' positive or appropriate beliefs and their classroom practices. They often use as an excuse that curricula do not provide space and time for creativity by Sak [23] and that, in addition, the freedom to depart from established rules and procedures leads to disruptions in the normal development of the classroom [24].

In the study by Katz-Buonincontro, et al. [25], five aspects linked to teaching and creativity emerged where teachers had different views: teaching for creativity as a component of teaching success, the creative capacities of teaching, the creative potential of students, the importance of creativity for students' learning, and the freedom to express new ideas. Gralewski [26] conducted interviews with teachers in which he observed that they described creative learners mainly in terms of their personality traits relevant from a creativity perspective, cognitive predisposition towards creativity, motivation, artistic ability, intelligence and participation in school. Teachers' beliefs about the characteristics of creative children are of relevance. Paek et al. [27] showed that teachers tended to have more misconceptions about undesirable characteristics in creative children than about desirable characteristics in creative children. These teacher misconceptions may hide the creative potential of children who do not manage their undesirable characteristics in a constructive way.

It is also of great interest to know teachers' ideas about creativity and its relation to teaching practice. In this regard, Cropley et al. [28] study found differences in ideas about creativity and its teaching among teachers by gender, discipline, level (primary vs. secondary). Newton and Newton [29] developed a questionnaire, based on creative or reproductive activities in sciences, to assess teachers' ability to recognize situations that may or may not develop creativity in students. The results showed a significant fraction of teachers who confuse the manipulative character of an activity with the creativity involved. Rubenstein et al. [30] pointed out significant differences between in-service and pre-service teachers, in terms of optimism and self-efficacy related to environmental support and the development of creative thinking. Another concern for researchers is the necessary connection between disciplinary knowledge and creativity development. Hetherington et al. [31] explored educators' perspectives on the relationship between science and creativity in education. They found that while there was broad agreement that science is a creative activity, there was controversy over the role of scientific knowledge in creativity: some educators emphasized its importance in scientific inquiry, while others considered creativity to be a more generic set of skills in which disciplinary knowledge plays a secondary role.

1.2. Factors Influencing Teachers' Beliefs and Actions About Creativity

Identifying factors associated with teachers' beliefs about school creativity can help structure their analysis and utilization in teacher training, both initial and in-service, to make teachers more aware of the value of developing creativity in their students and more likely to conduct educational activities that stimulate creativity [29]. A comprehensive analysis of the factors that influence

teachers' beliefs about creativity was developed by Sternberg et al. [32]. These researchers identified a variety of influences, from individual differences and personal experiences to environmental factors, that shape educators' perceptions and attitudes towards creativity. They highlighted the importance of considering teachers' self-perception of creative efficacy, implicit theories about creativity, the pedagogical strategies employed, classroom dynamics, and initial training as crucial elements in understanding how creativity is promoted in the educational environment. More recently in the exhaustive literature review carried out by Han and Abdrahim [33], many factors that may influence teacher creativity were highlighted. However, we will focus on some of the studies which, because of their subject matter or because they have not been included in this review, are of particular interest in this study.

Hong et al. [34] found that teachers with sophisticated epistemological beliefs (i.e. beliefs about the nature of knowledge and knowing), high intrinsic motivation for creative work, and who have a clear goal orientation tend to engage in teaching practices that foster creative thinking in their students. In the interviews conducted by Hidayat and Mason [35] with teachers, the three factors that most influence teachers' creativity were: their knowledge and experience in teaching, their motivation (intrinsic and extrinsic) to be creative and the use of ICT. From a set of responses provided by teachers the results of the analysis by Huang et al. [36] showed that metacognition and enthusiasm were strong predictors of creativity teaching. In addition, willingness to collaborate with other teachers in teaching, being involved in innovation at school, and having access to equipment and resources were the factors most strongly associated with teaching creativity.

Finally, Rubenstein et al. [30], through the development and validation of the *Teaching for Creativity Scales*, identified four factors that influence teachers' perceptions of teaching for creativity: teacher self-efficacy, environmental encouragement, social value, and student potential. These authors also found that teachers' self-perceptions of their own creativity are highly correlated with their self-efficacy as teachers. Furthermore, there was a significant correlation between the social value attributed to creativity, student potential, and teacher self-efficacy, indicating that teachers who value creativity also believe in their ability to foster it in their students.

1.3. Aims and Hypothesis

The present study aimed at elucidating teachers' perceptions of creativity in science teaching and learning during initial training, and to identify factors that, in their view, influence classroom practices that enhance creativity. One of the earliest studies on teachers' beliefs about creativity was conducted by Diakidoy and Kanari [1] in Cyprus. This research showed that prospective teachers often link creativity primarily with artistic endeavours and regard creative outputs as novel, though not necessarily appropriate. Since then, similar research has been carried out in various countries and cultural settings. The current study replicates Diakidoy and Kanari's work within the Latin American context, where research on this topic remains scarce.

Therefore, the hypothesis of this study was stated as follows:

H: The conceptions about creativity in science of pre-service Colombian teachers will be similar to that obtained by Diakidoy and Kanari [1] with pre-service Cypriot teachers.

While it cannot be definitively supported, it is also expected that the thinking of these pre-service science teachers will show ideas about school creativity very similar to those obtained in other international studies conducted with in-service teachers of different specialities [21].

2. Materials and Methods

2.1. Participants

Students from the first and last semesters of teacher training programs at two large universities located in two prominent cities in Colombia were selected. The sample consisted of 152 pre-service teachers, students from the first (1st, 2nd, and 3rd) and last semesters (8th, 9th, and 10th) of two specific university degrees in science education for secondary education. Of these, 52 were studying for a degree in Natural Sciences and Chemistry (27 women and 25 men), and 100 were pursuing a degree in Physics and Mathematics (33 women and 67 men). None of the participants declared a

"non-binary" gender in this study, despite having the option to do so, likely due to the still present pressures in the sociocultural environment of the sample.

All groups (intact) from the respective specialties in each semester and university were taken. Although all participants lacked any peculiar or differential traits in their population (science teachers in training in Colombia), there was no random sampling. Therefore, the results obtained lack sufficient external validity and should not be extrapolated.

2.2. Instrument and Variables

The questionnaire created and used by Diakidoy and Kanari [1] was adapted and applied. The questionnaire retained its original structure, although 6 items were added to collect sociodemographic information. The first part, A, consists of a group of 7 open-ended items. Two of these items first ask for a yes/no answer, but then request an explanation. The items in part A are aimed at conceptualizing creativity by teachers, such as: definition of creativity (1A), relationship between creativity and intelligence (2A), role of prior knowledge in creativity (3A), teachers facilitating creativity (4A), examples of creativity (5A), the curriculum in the manifestation of creativity (6A), and the areas of knowledge conducive to creativity (7A). The second part, B, consists of 20 closed-ended questions, involving selecting options that are offered. These items collectively inquire about teachers' thoughts on how to foster creativity. For instance, item (1B) explores whether creativity is present in all or some children, types of tasks that facilitate school creativity (2B), creativity across various domains (3B), frequency of encountering creative children (4B), personal characteristics and skills associated with creativity (5B), students likely to be creative (6B), creativity and a high degree of knowledge (7B), creativity as a characteristic of all people (8B), creative thinking different from thinking used in school (9B), creative thinking different from that used in everyday life (10B), intelligence and creativity (11B), creative outcomes (12B), use of paper clips and a creative child (13B), creativity in history (14B), innate creativity or facilitated creativity (15B), academic performance and creativity (16B), factors that influence creativity (17B), a new way to add and creativity (18B), opportunities to manifest creativity in school (19B), and environmental factors that foster creativity (20B).

To adapt the questionnaire, it was first translated from English to Spanish by an expert. Then, 3 bilingual professionals were asked to express any possible disagreements between the translated and original questionnaire to ensure that both versions were equivalent in content and meaning. This led to some adjustments in the wording of some items. After this, fields to collect sociodemographic data and instructions were added, and the complete questionnaire was edited into a *Google Forms* format. A pilot test was then conducted with a group of 20 participants from the areas of natural sciences and physics (not belonging to the sample of the current study) to identify the level of clarity and comprehension of the adapted questionnaire. After collecting the few doubts from the participants, modifications were made to the instructions to clarify and make sense of the contents of the questionnaire, resulting in a version considered suitable for application in a sample of pre-service teachers.

2.3. Data Collection Procedure

Authorization was obtained from the coordinators and faculty of the teacher training programs at each university for the application of the questionnaire in the classrooms on agreed days and times. In each classroom, participants were informed about the purpose of the study and consent and voluntary participation were requested. Total anonymity was assured and guaranteed at all stages of the study. Written instructions were then distributed, and any doubts clarified before the participants completed the instrument. The questionnaire was filled out individually using the *Google Forms* application. Participants accessed the questionnaire via emails and QR codes.

2.4. Data Analysis

R-Studio and Jamovi software applications were used for the descriptive and inferential statistical analysis of the qualitative and quantitative data obtained, respectively. Textual qualitative

responses were subjected to coding using a text mining technique. Before applying this technique, a review of the responses provided by the participants was conducted to identify trends and patterns associated with the future teachers' thinking about the different aspects of the questionnaire. With the response patterns of the participants already identified, an RStudio script was developed to code concepts of creativity, the area of knowledge that promotes creativity, examples of creativity found in students, as well as various factors that limit or promote the development of creativity in students. The coded data were then exported in Excel format to the free software Jamovi for statistical processing, which primarily consisted of counts, proportions, and goodness-of-fit analysis using the Ji-square test.

3. Results

Based on the content of the Diakidoy and Kanari [1]; hereafter referred to as DK for simplicity) questionnaire and the analysis by the authors themselves, the following groups of variables were differentiated in the study: (a) conception of creativity; (b) individual differences in creativity; (c) factors influencing the manifestation of creativity; and (d) facilitation of creativity.

3.1. Conceptions of Creativity

Table 1 presents the main definitions of creativity obtained from the sample after the coding process of responses to item 1A.

Table 1. Different definitions of creativity elaborated by Colombian pre-service science teachers.

Creativity is...	Percentage
The ability to invent ideas, forms, or concepts from existing knowledge, generating original knowledge that can facilitate the solution of everyday problems.	52.6
The human capacity to construct and invent solutions to specific problems.	8.6
The process of innovation, transformation, and continuous change.	6.6
The capacity or facility to invent.	6.6
It is the opportunity to envision present and future knowledge and experiences through imagination and innovation.	6.6
Imagination, motivation, and ingenuity that a person can have in the creation of something.	10.5
Different ways of structuring thoughts, ideas, and developing activities.	9.2

Note: Some individuals provided more than one definition, so the percentages do not add up to 100.

Table 2 summarises various examples cited by participants that demonstrate student creativity. The most common examples pertain to artistic fields or the integration of arts and literature with sciences. Additional examples include a diverse range of activities and games, such as problem-solving, teaching, experimentation, modelling, formulating questions, and undertaking projects.

Table 2. Examples of situations and activities considered as creative by the participants.

Manifestations of creativity (item 5A)
Teaching physics through science fiction or cinema.
An 11-year-old student, in fifth grade, needed to create a story that demonstrated the importance of numbers. The story she wrote included sentences like "Ramón woke up and heard the news saying it's "\$%\$#" (sic) in the morning." The student substituted numbers with "scribbles," and reading them produced unintelligible but amusing sounds. The entire story followed this dynamic, and we could understand

her intention to highlight the importance of numbers in everyday life, and how they suddenly disappeared.

- Creating an educational game for teaching mathematics using recycled materials.
- Conducting an exhibition through a radio play.
- Developing video games that explain physical phenomena.
- In an exercise to determine the area of an irregular shape, the teacher suggested drawing lines from the vertices of the figure. However, a student, without consulting the teacher, used a method of correspondences and proportions to achieve the same result.
- Children learn to count more easily when they go outdoors and collect stones or sticks than when they do so by repeating from a board or a textbook.
- Programming a physical system on the Microbit platform.

Table 3 displays the percentages of participants in the current study who selected certain response options on a group of items, which reflect aspects of their conception of creativity. It also shows the Chi-square tests computed to contrast the distribution of option choices against the null hypothesis (equality of proportions). These data are compared with those obtained in the study DK.

Table 3. Conceptions of creativity: comparison between the present study and Diakidoy and Kanari’s.

Conception	Items	Diakidoy & Kanari (1999) n (%)	Present Study n (%)
Creativity is related to "doing things."	1A	19 (38.7%) $\chi^2(1) = 2.47$	13 (8.6%) $\chi^2(1) = 104.45^{**}$
Creativity is associated with self-expression, expression of potential, and personal needs.	1A	7 (14.3%) $\chi^2(1) = 25.00^{**}$	0 (0%)
Creativity is explicitly linked to problem-solving and critical thinking.	1A	17 (34.7%) $\chi^2(1) = 4.60^*$	14 (9.2%) $\chi^2(1) = 101.16^{**}$
Creativity is related to insight, imagination, and inventiveness.	1A	7 (14.3%) $\chi^2(1) = 25.00^{**}$	16 (10.5%) $\chi^2(1) = 94.74^{**}$
Examples of creativity in artistic and/or literary contexts are provided.	5A	34 (69.30%) $\chi^2(1) = 7.47^{**}$	57 (37.5%) $\chi^2(1) = 9.50^{**}$
Examples of creativity related to conceptual change, hypothesis formation, hypothesis testing, and problem-solving strategies are given.	5A	15 (30.7%) $\chi^2(1) = 7.37^{**}$	95 (62.5%) $\chi^2(1) = 9.50^*$
A product must be novel to be considered creative.	12B	31 (63.3%) $\chi^2(1) = 3.45^*$	101 (66.4%) $\chi^2(1) = 16.45^{**}$
A creative product must be appropriate or useful.	12B	5 (10.2%) $\chi^2(1) = 31.04^{**}$	15 (10%) $\chi^2(1) = 97.92^{**}$

A creative product does not necessarily have to be appropriate: A child who discovers a new strategy for performing a three-digit addition is creative, even if the strategy leads to an incorrect solution.	18B	37(75.5%) $\chi^2(1) = 12.75^{**}$	81(53.3%) $\chi^2(1) = 0.66$
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(*) $p < .05$; (**) $p < .01$.

3.2. Individual Differences in Creativity

Creativity can be conceived as a rare capability, present only in a few people throughout history, or, conversely, as a human skill that is present in many individuals and can be developed. Several items in the questionnaire of DK study allow for assessing participants' conceptions. Table 4 collects the results obtained in these items in the present study and compares them with those in DK.

Table 4. Frequency of manifestation of creativity in the students: comparison between the present study and Diakidoy and Kanari's

Options in the questionnaire	Item	Diakidoy & Kanari (1999) n (%)	Present Study n (%)
Some children are more creative than others.	1B	38(77.6%) $\chi^2(1) = 14.88^{**}$	11(70.4%) $\chi^2(1) = 111.18^{**}$
Children tend to display their creativity in a variety of forms and contexts.	3B	40(81.6%) $\chi^2(1) = 19.61^{**}$	143(94.1%) $\chi^2(1) = 118.13^{**}$
Creativity is a common phenomenon in the school population: educators encounter creative children very often or frequently.	4B	38(77.5%) $\chi^2(1) = 14.88^{**}$	70(46.1%) $\chi^2(1) = 0.95$;
Creativity is not a characteristic of all individuals.	8B	37(75.5%) $\chi^2(1) = 12.76^{**}$	21(13.8%) $\chi^2(1) = 79.61^{**}$
Products are considered creative if they are novel to the social group in which the person producing them belongs.	12B	8(16.3%) $\chi^2(1) = 22.22^{**}$	44(28.9%) $\chi^2(1) = 26.95^{**}$
Children who discover on their own how to use a paper clip are creative.	13B	34(69.4%) $\chi^2(1) = 7.37^{**}$	117(77,0%) $\chi^2(1) = 44.237^{**}$

(*) $p < .05$; (**) $p < .01$.

3.3. Factors Influencing the Manifestation of Creativity.

3.3.1. Personality

Table 5 shows the percentages in the perception of creative personality traits and the differences between the present study and DK.

Table 5. Personal traits associated with creativity: comparison between the present study and Diakidoy and Kanari's.

Personal traits (item 5B)	Diakidoy & Kanari (1999) (%)	Present Study (%)
Imagination	100	98.7
Ability to set one's own goals	93.9	75.0
Self-confidence	91.8	90.1
Divergent thinking	89.8	51.3

Independence	83.7	57.9
Autonomy	83.7	84.9
Critical thinking	81.6	75.0
Multiple interests	73.4	67.1
Ability to establish one's own rules	69.4	52.0
Innate talent	67.3	34.9
Artistic inclinations	67.3	60.5
Ability to identify and define problems	51.0	15.8
Intelligence	38.7	52.0
Analogical reasoning	32.6	0.0
Need for praise and reinforcement	28.6	18.4
Need to avoid mistakes	14.3	8.6
Desire to accept guidance from others	12.2	52.0
Need for recognition and acceptance	10.2	23.7
Convergent thinking	10.0	28.3
Fear of failure or making mistakes	0	9.9
Obedience to rules and societal expectations	0	7.9

3.3.2. Environment

Table 6 details the environmental factors that, according to participants, influence the manifestation of creativity.

Table 6. Environmental factors influencing the manifestation of creativity in the classroom.

Environmental Aspects (Item 20B)	Diakidoy & Kanari (1999) (%)	Present Study (%)
Opportunities to correct one's own mistakes	92.0	80.9
Emphasis on autonomy and independence	100	79.6
Emphasis on discovery learning	98.0	79.6
Emphasis on collaborative learning	57.1	75.7
Emphasis on intrinsic motivation	92.0	74.3
Opportunities to question theories and assumptions	79.6	74.3
Acceptance of all work outcomes	63.2	48.0
Emphasis on knowledge	14.3	42.1
Frequent and detailed feedback	28.6	41.4
Choice in tasks	83.7	34.2
Use of external rewards	24.5	32.9
Emphasis on competition	18.4	32.2
Frequent praise	28.6	29.6
Frequent evaluation of outcomes	16.3	28.9
Emphasis on following instructions	8.1	12.5

3.4. Facilitating Creativity

In line with the value given to the environment, a large percentage of future science teachers (83.6%, compared with 93.9% in DK) believe that creativity can be facilitated in all individuals (item 15B; $\chi^2(2) = 172.75$; $p < .001$) and that teachers can foster creativity in their students (98.7% in the present study, close to 93.9% in DK; item 4A, $\chi^2(1) = 144.11$, $p < .001$).

Table 7 shows examples of teaching actions that can encourage creativity, as frequently mentioned in the present study.

Table 7. Actions teachers can take to promote creativity in their students.

Teachers can promote creativity in students... (item 4A):
Implementing practices that awaken students' curiosity.
Using a variety of classroom resources that pique students' curiosity, stimulate their thinking, and guide their methodology towards knowledge creation, whether through experimentation, inquiry, art, or other methods that can enhance students' creativity.
Through teaching strategies that include reading and writing components, for example, the works of Jules Verne could foster creativity in physics education.
Through literature, which invites readers to create scenarios based on what they read, whether fantastical or realistic stories, compelling the brain to imagine and see things differently.
When they are allowed to solve problems using various tools instead of being limited to a single one.
Creating images, characters, activities, readings, dynamics, and situations in which students can choose academic, intellectual, and imaginative tools, among others.
Providing activities open to discussion that can be solved in multiple ways.
Children are more creative when taught through emotions and play, when they are allowed to interact with their peers, and when they are listened to.
When they are given a leading role, presented with challenges, invited to create strategies, and given the opportunity to express their ideas to solve problems, considering the diversity of approaches.

Responses to question 2B, shown in Table 8, indicate that the type of tasks can facilitate or limit creativity, according to the participants' judgment:

Table 8. Types of tasks that promote creativity in science.

Type of tasks promoting creativity in science	Diakidoy & Kanari (1999) (%)	Present Study (%)
Open-ended questions	95.9%	91.4%
Questions and problems that take multiple responses	98.0%	85.5%
Questions and problems for which students have relevant prior knowledge	Nr*	71.1%
Questions and problems that students have encountered before	Nr*	55.9%
Questions and problems that are unfamiliar to students	67.3%	51.3%

Note: Nr* stands for "Not reported".

The future teachers in the current study, like those in DK, identified various factors that facilitate or inhibit creativity in science education, as shown in Table 9.

Table 9. Influence of science knowledge on creativity: comparison between the present study and Diakidoy and Kanari's

Options in the questionnaire	Item	Diakidoy & Kanari (1999) (%)	Present Study (%)
Prior knowledge plays an important role in creativity.	3A	77.6%	86.8%
The national curriculum does not facilitate creativity.	6A	65.3%	51.3%
Good students do not have greater chances of being creative than average students.	6B	75.5%	61.2%

Creative thinking is no different from the thinking required to solve problems at school.	9B	55.1%	46.7%
Creative thinking is not different from the thinking used to solve problems in everyday life.	10B	87.8%	29.6 %
Academic performance is a good indicator of creativity.	16B	10.2%	24.3%
There are many opportunities at school for students to express their creativity.	19B	89.8%	73.0%

4. Discussion

4.1. Conceptions of Creativity

In the current study, over half of the participants (52.6%) viewed creativity as the ability to generate original ideas, forms, or concepts from existing knowledge to solve everyday problems. A minor proportion (10.5%) emphasized the role of imagination, motivation, and ingenuity in the creative process. Additional perceptions include the capability to devise solutions (8.6%), the process of innovation and change (6.6%), and the ability to structure thoughts and activities uniquely (9.2%). These conceptions exhibit some quantitative, though not qualitative, differences compared to the DK study (Table 3) and align with findings from similar studies in various international contexts. Typically, teachers in such studies defined creativity as an endeavour that necessitates imagination [8,9,14], certain intellectual traits [7,9,11,14,19], and results in innovative and original products [8,9,11,14,23]. However, most examples illustrating student creativity cited by the participants (Table 2) related to artistic fields or the integration of arts and literature with sciences, a trend consistently observed in similar studies [21].

4.2. Individual Differences in Creativity

In this study, there was a prevalent belief that creativity is an attribute inherent in all individuals (Table 4), with a significantly higher percentage than in the DK study (86.2% vs. 24.5%, respectively), and higher than in other research such as Aljughaiman and Mowrer-Reynolds [14], where 64.0% of participants believed this, or Kampylis et al. [16], where 48.4% of teacher training students shared this view. This high percentage aligns the beliefs of the pre-service teachers in our sample more closely with those of academic researchers in the field of creativity. Regarding the frequency of creativity's manifestation in school settings, the current study noted a marked decrease in the perception that educators regularly encounter creative children, compared to the findings in the DK study (46.1% vs. 77.5%). Results from other studies vary: for instance, teachers in the Aljughaiman and Mowrer-Reynolds [14] study observed that more than 50% of their students displayed creative traits, whereas participants in the earlier study by Fryer and Collings [37] generally considered creativity to be a rare attribute.

4.3. Factors Influencing the Manifestation of Creativity

When evaluating the percentages for traits indicative of a creative personality, the correlation between the rankings in the current study and the DK study was notably high (Spearman-q = 0.82; p < .001). This indicates that future science teachers have similar perceptions of creative students' personalities. Imagination was deemed essential by nearly all participants in both studies (100% in DK, 98.7% in the current study), underlining its pivotal role in defining a creative personality. Similar observations were reported by [18,24], and by Sak [23]. Conversely, the ability to identify and define problems was only recognized by 15.8% of participants in this study.

Intelligence was commonly linked with creativity, as indicated by high percentages in both the current study (84.2%) and the DK study (73.5%). This aligns with prior research where teachers frequently equated creativity with high intellectual capability [21] and generally associated creativity

with students who demonstrated high academic performance [24] or overall academic proficiency [7].

Among the intellectual and personality traits considered essential for creativity, divergent thinking was significant but slightly less so in this study compared to DK (51.3% vs. 89.8%). Other studies also emphasize its importance for creative behaviour [11,14]. Critical thinking was another prominent trait (75.0% in this study vs. 81.6% in DK), and experts often link it to creative behavior, alongside risk-taking, questioning authority, and nonconformity [21]. Participants also frequently highlighted the importance of setting personal goals (75.0%) and rules (52.0%), as well as independence and autonomy (84.9%). In contrast, traits like obedience and conforming to expectations were rarely valued (7.9%).

Most pre-service teachers in this study agree that the classroom environment significantly influences the expression of students' creativity, consistent with prior findings [16,38,39]. Specific teacher actions were noted for their impact, such as providing opportunities for students to correct mistakes (80.9% in this study vs. 92.0% in DK), promoting students' autonomy (79.6% in both studies), encouraging the pursuit of solutions to challenging problems over extended periods, and fostering the communication of unconventional ideas.

Differences emerged in certain areas; for example, while discovery learning was more emphasized in DK than in the current study (98.0% vs. 79.6%), the opposite was true for collaborative learning (75.7% in this study vs. 57.1% in DK). Nonetheless, the correlation between percentage rankings in both studies remained very high (Spearman- ρ = 0.89; p < .001), indicating similar underlying criteria in these assessments.

4.4. Facilitating Creativity

When asked to identify tasks or methods they believed could elicit creative responses from students, only a few participants could specify particular tasks or teaching methods; the majority provided general responses, indicating a lack of familiarity with specific approaches (Table 7). However, when presented with various types of tasks (item 2B), participants recognized their potential for fostering creativity at rates similar to those in the DK study (Table 8), especially in open-ended questions and problems that do not have unique solutions.

A significant finding from the current study is the acknowledgment of the critical role of prior knowledge in fostering creativity, with a notable 86.8% of participants agreeing on its importance, aligning with the high percentages observed in the DK study. There was also a consensus between the two studies regarding the lack of a direct correlation between academic performance and creativity.

5. Conclusions

The hypothesis of this study was that the perceptions of pre-service Colombian science teachers regarding creativity would align with those observed by Diakidoy and Kanari [1] in their research with Cypriot teacher trainees. Within its confines, the data support this hypothesis, suggesting that the study conducted in Colombia serves as a replication of the Cypriot study.

Secondly, the definitions of creativity articulated by these Colombian pre-service science teachers diverge from those advanced by researchers, who often define creativity in psychological, cognitive, and metacognitive terms, such as fluency, flexibility, and originality. Nonetheless, such discrepancies have also been noted in other studies involving both active and pre-service teachers. However, when comparing the current study with those conducted in different countries and cultural contexts, the disparities observed here display significant qualitative similarities.

Thirdly, it is crucial to acknowledge the limitations of this study, primarily that the sample is not representative of all Colombian science teachers, being sourced only from two major universities in two principal cities and focusing solely on science teachers. Consequently, it is imperative to expand the sample size before using these findings to formulate recommendations for teacher training programs aimed at fostering creativity in the classroom.

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