



## CREATIVE THINKING SKILLS OF PRE-SERVICE SCIENCE TEACHERS BASED ON THE PISA FRAMEWORK

Agung Mulyo Setiawan<sup>1</sup>, Nuryani Rustaman<sup>2</sup>, Lilit Rusyati<sup>3</sup>, Parlindungan Sinaga<sup>4</sup>  
<sup>1,2,3,4</sup>Science Education Study Program, Universitas Pendidikan Indonesia, Bandung, Indonesia

### Article Info

#### Article history:

Received 08/03/2026

Accepted 22/04/2026

Published 30/04/2026

#### Keywords:

Creative Thinking;

PISA Framework;

Pre-Service Science Teacher;

Profile

### ABSTRACT

Creative thinking is one of the essential skills required in the twenty-first century and constitutes a core component of the pedagogical and professional competencies that teachers are expected to possess. In response to this urgency, this present study aimed to examine the profile of creative thinking among pre-service science teachers using the PISA framework. The research instrument employed three PISA 2022 creative thinking test items to measure creative thinking scores and to classify the creative thinking levels of 61 pre-service science teachers. Within the PISA framework, creative thinking is operationalized through 3 competencies: Generate Diverse Ideas (GDI), Generate Creative Ideas (GCI), and Evaluate and Improve Ideas (EII). A quantitative approach with a cross-sectional research design of population in time was applied in November 2025 and evaluated with the RASCH model, descriptive, and discriminant analysis. The RASCH model analysis indicated high item reliability but low person reliability, which can be attributed to the limited number of test items used in the assessment. The RASCH analysis also confirmed variations in the levels of the GDI, GCI, and EII competencies. Descriptive analysis revealed that the majority of pre-service science teachers were classified within the moderate and low creative thinking categories, while only a small proportion reached the high category based on frequency distribution results. Furthermore, discriminant analysis demonstrated that the GDI and EII competencies served as the primary predictors for classifying individuals into creative thinking categories. This study contributes by providing an empirical overview of the creative thinking skills profile of pre-service science teachers and highlighting the importance of strengthening GDI and EII competencies in the design of science learning in schools.

*This is an open-access article under the [CC BY-SA](#) license.*



### Corresponding Author:

**Lilit Rusyati**

Science Education Study Program, Universitas Pendidikan Indonesia, Bandung, West Java, Indonesia

Email: [lilitrusyati@upi.edu](mailto:lilitrusyati@upi.edu)

## 1. INTRODUCTION

Creative thinking is a cognitive process required for engagement in creative activities. In the Programme for International Student Assessment (PISA) 2022, Creative thinking can be understood as the ability to effectively participate in the processes of producing, assessing, and refining ideas, which ultimately contribute to novel and meaningful solutions, the advancement of knowledge, and the expression of imaginative insights with real impact (OECD, 2023a). The PISA

creative thinking framework emphasizes three core competencies: generate diverse ideas, generate creative ideas, and evaluate and improve ideas (OECD, 2023a). Results from PISA 2022 indicate that Indonesian students' creative thinking performance remains below the OECD average. The result suggests that many students experience difficulties in producing diverse and original ideas and in developing creative solutions to contextual problems. This finding serves as a critical signal for policymakers regarding the urgency of strengthening creative thinking within the national education system.

The urgency of strengthening creative thinking skills among pre-service teachers has become increasingly significant within the characteristics of PISA, which emphasizes literacy, problem-solving, and higher-order thinking abilities. PISA does not merely assess basic cognitive skills, it also requires individuals to generate innovative solutions in complex and unstructured situations (OECD & UNICEF, 2021). Therefore, pre-service teachers need to be equipped with creative thinking competencies to design learning processes that are adaptive, contextual, and oriented toward developing 21st-century skills (OECD, 2023a). Without these abilities, future teaching practices tend to be reproductive and less effective in encouraging students to think critically and creatively. Furthermore, integrating the PISA framework into teacher education can serve as an effective strategy to bridge the gap between global demands and classroom practices. This integration also has implications for improving pedagogical quality, where teachers act not only as knowledge transmitters but also as facilitators who promote idea exploration and creative problem-solving (Chugh & Tiwari, 2024). In addition, strengthening creative thinking among pre-service teachers contributes to improving students' performance in international assessments while enhancing national educational competitiveness. Thus, the development of creative thinking on the pre-service teachers should be thought in teacher education professional development. This effort requires systematic support through policies, curriculum design, and innovative and sustainable teaching practices (OECD, 2023b).

Teachers' understanding of creative thinking skills constitutes a crucial aspect in responding to the increasingly complex demands of 21st-century learning (Alabbasi et al., 2022). These skills are not only associated with the ability to generate new ideas, but also reflect flexibility, originality, and the capacity for elaboration in addressing learning-related problems. Within the framework of teacher competency standards, the ability to comprehend and foster creative thinking skills forms an integral part of the pedagogical and professional competencies that every educator is expected to possess (Permendiknas RI No.16, 2007). However, classroom realities indicate that many teachers have not yet fully grasped the concept or effectively implemented creative thinking skills in their daily teaching practices (McLure et al., 2024). This condition is often influenced by limited training opportunities, insufficient access to relevant learning resources, and a relatively heavy administrative workload. As a result, instructional processes tend to focus on lower-order cognitive achievements and provide limited space for creative exploration. Therefore, systematic and sustained efforts are needed to enhance teachers' understanding and capacity to integrate creative thinking skills into the learning process (OECD, 2023a).

The low level of students' creative thinking achievement cannot be separated from the role of teachers in the learning process. Pre-service teachers must be equipped with creative thinking skills to enable them to design meaningful and contextual learning experiences that encourage students' exploration of ideas (Albers et al., 2025). Within teachers' professional and pedagogical

competencies, creative thinking is essential across various dimensions, including the design of innovative instructional strategies, the development of learning media and resources, the construction of assessment items, and classroom management that is adaptive to students' diverse characteristics (Permendiknas RI No.16, 2007). Without adequate creative thinking skills, pre-service teachers are likely to reproduce routine and iterative teaching practices that offer limited support for the development of students' Higher-Order Thinking Skills (HOTS) (Yuan et al., 2022).

A number of previous studies have examined the creative thinking of pre-service teachers using assessment instruments and frameworks derived from Torrance Test of Creative Thinking (TTCT) (Torrance, 2018). Within the Torrance framework, creative thinking is characterized by fluency, flexibility, originality, and elaboration (Torrance, 2018). With this instrument, a general creativity of pre-service teachers is measured to obtain their profile categories with various objectives (Huang & Wang, 2019). In learning practice, pre-service teachers' creative thinking has typically been measured before and after instructional interventions employing specific models and approaches. There are two versions of TTCT, Figural and Verbal, often used by researchers (Alabbasi et al., 2022). Based on the last study from preschool children to adults with gender, both of Verbal and Figural are highly related, but Figural was a more comprehensive, reliable and valid than Verbal (Kim, 2017). However, the validity of the general creative thinking test is still a long discussion for researchers in measuring the profile of pre-service teacher creativity due to a certain science subject (Ramly et al., 2022). The reason is that to solve various problems in science, various systematic and accurate explanations are needed.

In response to this challenge, it is essential to explore a range of strategic and evidence-based approaches aimed at enhancing the creative thinking skills of pre-service science teachers. For example, researchers used Science-Technology-Engineering-Mathematics (STEM) learning, Problem Based Learning (PBL), Project Based Learning (PBL), Design Thinking, and etc (Agustin et al., 2021; Rao et al., 2022; Rohman et al., 2024; Utami et al., 2021). However, most of these studies rely on the Torrance framework and rarely adopt international assessment frameworks such as PISA. This situation creates a gap between the development of creative thinking in pre-service science teachers and the way students' creative thinking is assessed. The creative thinking of pre-service science teachers is predominantly developed and measured using the Torrance framework, while students are evaluated using the PISA framework. It is not a matter of determining which test of creative thinking (whether the Torrance or the PISA framework) is superior, but rather of examining their relevance. This relevance can be evaluated based on the practical foundations within instructional practices related to student creative thinking (Alabbasi et al., 2022). An important question arises: have teachers been engaging in teaching creative thinking or teaching for creative thinking? Since the release of the PISA creative thinking results, many studies have undertaken reflections on existing teaching practices through the lens of the PISA framework (McLure et al., 2024). Also, this raises another important question: how can students' creative thinking, as defined by PISA, improve in the future if their teachers are not equipped with the same conceptual framework? This misalignment in intervention warrants serious reflection among researchers, practitioners, and policymakers in Indonesia. To date, there is no empirical evidence demonstrating whether individuals who exhibit high levels of creative thinking within the Torrance framework also demonstrate similarly high levels within the PISA framework.

Addressing this research gap, our present study introduces a novel approach by assessing the creative thinking skills of pre-service science teachers using the PISA 2022 framework. While PISA traditionally measures students' creative thinking, this study extends its application to pre-service teachers in order to identify their readiness to design and implement creative instruction. The PISA framework is considered more contextual, as it emphasizes the ability to generate, evaluate, and refine ideas within real-life situations, aligning with the concept of little-C creativity (Kaufman & Beghetto, 2009). To date, limited studies have examined the creative thinking profiles of pre-service science teachers using the PISA creative thinking framework. The contribution of our research is expected to provide new insights into the creative thinking profiles of pre-service science teachers, while also bridging their competencies with national education standards and 21st-century skills. Accordingly, this study aims to analyze the creative thinking profiles of pre-service science teachers based on the PISA framework as an evaluation for the teacher's readiness in developing creative thinking in science learning. For further discussion, we also administered the PISA creative thinking assessment items to doctoral students in science education in order to examine the level of difficulty and to explore their perspectives of these tasks in the discussion.

## 2. METHOD

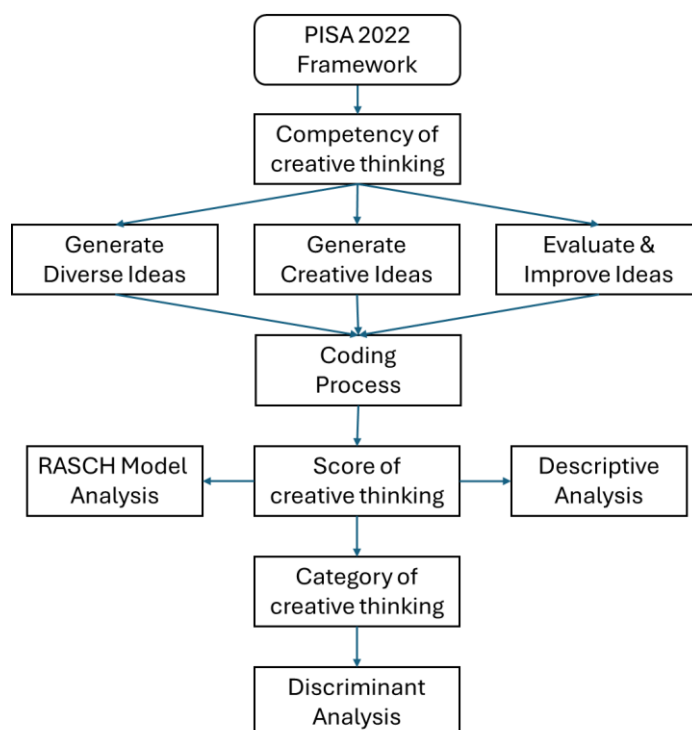


Figure 1. Research procedure

Based Figure 1, this study employed a quantitative approach with a cross-sectional research design (King et al., 2018; W. Creswell & David Creswell, 2018). Cross-sectional design means that data is collected only once (a snapshot), describes conditions at a specific point in time, and does not assess changes over time (Cohen et al., 2018). In this study, the creative thinking data of pre-service science teachers were collected in November 2025. The research was conducted at one university of Malang and involved 61 pre-service science teachers as respondents. These participants were drawn from three classes within the same student cohort, with approximately 20

students representing each class. Respondents were selected using a convenience sampling technique, with the inclusion criteria that they had completed coursework in science-related disciplines (biology, physics, chemistry, and Earth and Space Science) and were enrolled in their fifth semester. This sampling technique was used due to accessibility and cohort availability. The overall research procedures implemented in this study are illustrated in Figure 1.

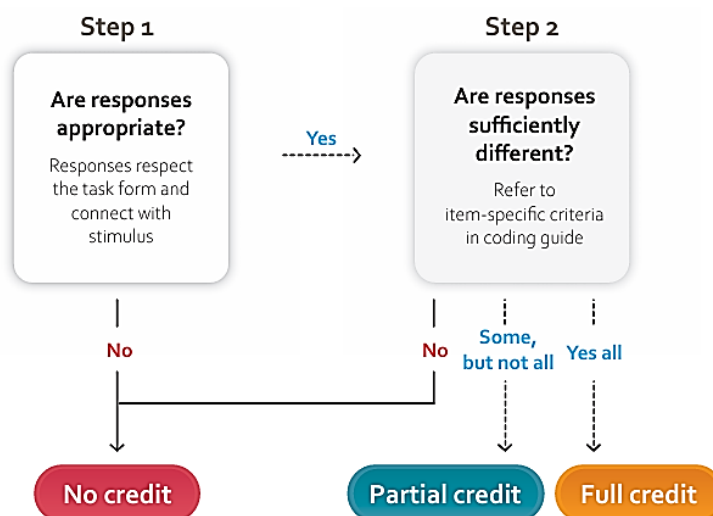


Figure 2. Coding process for GDI, Source: (OECD, 2023a).

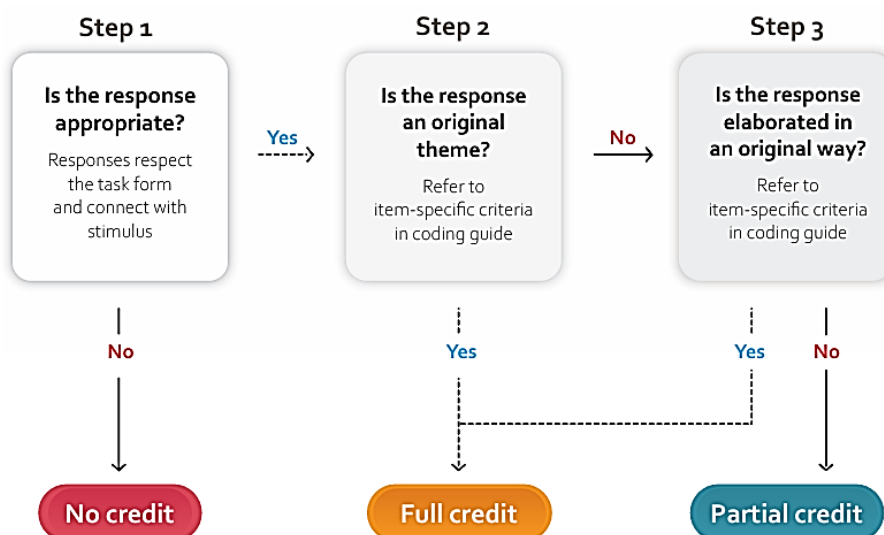


Figure 3. Coding process for GCI & EII, Source: (OECD, 2023a).

Based Figure 3, the research instrument consisted of a creative thinking test based on the PISA framework, which has undergone extensive validation and has been globally implemented in PISA 2022. Total of three essay-type items were used in the assessment, with each item representing one domain of creative thinking competence. These domains comprised: (a) Generate Diverse Ideas (GDI), (b) Generate Creative Ideas (GCI), and (c) Evaluate and Improve Ideas (EII) (OECD, 2023a). With respect to contextual domains, each item corresponded to one of the following contexts: (a) written expression, (b) social problem solving, and (c) scientific problem

solving (OECD, 2023a). Within the PISA item bank, each context can be applied to different competencies. Item 1 refers to GDI titled “Save the Bees”, item 2 refers to GCI titled “2983”, and item 3 refers to EII titled “Carpooling”. The limited number of items represents a limitation of the study while the specific items utilized in this research are provided in the appendix.

To obtain quantitative data, the scoring of the PISA creative thinking test involved two to three assessment steps, as depicted in Figures 2 and 3. This scoring methods has been declared valid based on a large-scale assessment conducted simultaneously in many countries with very large samples. Through this process, each participant’s written response was coded as 0 (no credit), 1 (partial credit), or 2 (full credit) (OECD, 2023a). Accordingly, each item or competency was assigned a score of 0, 1, or 2 to reflect the assessment outcome. To derive the overall creative thinking score, the coded scores for each competency were multiplied by a factor of 20 and then summed to determine the corresponding creative thinking category based on the PISA classification. The PISA creative thinking categories are presented in Table 1.

Table 1. Creative thinking category based on its score achievement

Type of Category	Level of proficiency	Min-max score	Characteristics of the tasks
High	6	48–60	Students can effectively generate original and diverse ideas for creative and problem-solving tasks, including those involving complex, abstract, and unfamiliar contexts.
	5	41–47	Students can generate original and varied ideas for a range of creative and problem-solving tasks.
Moderate	4	32–40	Students can engage in idea generation across various creative and problem-solving contexts.
	3	23–31	Students can produce one or more relevant ideas for simple to moderately complex tasks, including extended written responses that demonstrate imagination and build coherently on others’ ideas.
Low	2	15–22	Students can generate suitable ideas for basic visual and written tasks, as well as for solving familiar everyday social problems.
	1	6–14	Students can create very simple visual designs using basic or existing elements, and occasionally produce brief written outputs requiring limited imagination.
	Below level 1	0–5	Students perform below level 1.

Based Table 1, data analysis was conducted using the Ministep and SPSS software packages and involved several analytical techniques (Härdle et al., 2024). First, Rasch model analysis was performed to examine item reliability and person reliability for the three test items. Second, descriptive analysis was used to characterize the creative thinking competencies and overall creative thinking scores of the pre-service science teachers. Third, discriminant analysis

was employed to identify which competencies most strongly predicted the creative thinking categories of the pre-service science teachers.

### 3. RESULTS AND DISCUSSION

#### 3.1. Results of The Rasch Model Analysis

The Rasch model analysis provides comprehensive information regarding the quality of respondents' response patterns (person reliability) and the quality of the test used (item reliability). Based on the summary statistics, the person reliability score for the 61 respondents was 0.30, indicating poor reliability, whereas the item reliability score for the three test items was 0.89, indicating good reliability. This low person reliability indicates that the instrument may not adequately capture variations in respondents' abilities. Our finding suggests that while the consistency of respondents' answers was relatively low, the consistency and quality of the test items were strong. Consequently, the interaction between persons and items was suboptimal, which is reasonable given the limited number of items administered to each respondent. Another positive finding was the item separation value of 2.87, indicating that the test instrument was capable of effectively distinguishing between different groups of respondents as well as differentiating levels of item difficulty.

The Rasch model analysis also revealed variations in item difficulty levels based on the logit scale, as presented in Table 2. As shown in Table 2, Item 3 exhibited the highest logit value (+0.93 logit), indicating that it was the most difficult item among the three. Only 37 out of 61 respondents were able to answer item 3 correctly. The logit scale further indicates that the difficulty level of Item 3 was greater than Item 2 (-0.14 logit), while the difficulty of Item 2 was also greater than Item 1 (-0.79 logit). Accordingly, the items can be categorized by difficulty level as follows: item 3 was difficult, Item 2 was moderate, and Item 1 was easy. As shown in the Appendix, item 3 corresponds to the Evaluate and Improve Ideas (EII) competency domain, Item 2 to Generate Creative Ideas (GCI), and Item 1 to Generate Diverse Ideas (GDI). This pattern aligns with the PISA 2022 creative thinking framework, which posits that EII items are generally more difficult, GCI items are of moderate difficulty, and GDI items are relatively easier (OECD, 2023a).

Table 2. Results of item statistics: measure & misfit order in Ministep

Count of the right answer of respondent	Total respondent	Measure (logit)	Outfit MNSQ	Outfit ZSTD	Point Measure Corr.	Item Questions
37	61	0.93	1.21	1.14	0.69	Item 3
59	61	-0.14	0.90	-0.40	0.71	Item 2
73	61	-0.79	0.84	-0.90	0.53	Item 1

Based Table 2, with respect to item validity, the results of the Mean Square (MNSQ), Z-standardized (ZSTD), and Point Measure Correlation (Pt. Measure Corr.) indices for each item showed that all three items met the criteria for being classified as fit (valid) instruments based on Rasch analysis. An item is considered fit if it satisfies at least two of the following three criteria:

$0.5 < \text{MNSQ} < 1.5$ ;  $-2.0 < \text{ZSTD} < +2.0$ ; and  $0.4 < \text{Pt. Measure Corr.} < 0.85$  (Andrich & Marais, 2019). The same criteria were applied to assess person fit. The results indicated that four respondents did not meet the minimum fit requirements based on the MNSQ, ZSTD, and Pt. Measure Corr. indices and were therefore excluded from the dataset. Consequently, the number of respondents included in subsequent analyses now was reduced from 61 to 57.

### 3.2. Results of The Descriptive Statistic Analysis

Descriptive statistical results for the GDI, GCI, and EII scores are presented in Table 3 and Figures 4, 5, and 6, respectively. As established earlier through the Rasch model analysis and the PISA 2022 creative thinking documentation, item 1 was classified as easy (GDI), item 2 as moderate (GCI), and item 3 as difficult (EII). Figure 4 shows that for the easy item, the proportion of respondents receiving full credit was highly dominant (61.40%), indicating that a large number of pre-service science teachers were able to respond correctly to the GDI competency.

Table 3. Statistical descriptive of GDI, GCI, and EII

Data	GDI	GCI	EII
N	57	57	57
Mean (M)	12.81	9.47	5.09
Std. Deviation (SD)	9.403	3.974	7.588

Based Table 3, for the moderately difficult item shown in Figure 5, a shift in dominance is observed, with the majority of respondents receiving partial credit (84.21%). This suggests that many pre-service science teachers were able to partially meet the requirements of the GCI competency but did not fully achieve complete responses. This shift in response patterns continued for the difficult item presented in Figure 6, where the no-credit category became the most dominant (64.91%). This indicates that a substantial proportion of pre-service science teachers were unable to provide correct responses for the EII competency. These findings further confirm the results of the Rasch model analysis, demonstrating that item 3 was more difficult than item 2 and item 1. Accordingly, the hierarchy of creative thinking competencies in the PISA framework, from lowest to highest level, is GDI, GCI, and EII.

By summing the GDI, GCI, and EII scores, the total creative thinking scores of the pre-service science teachers were obtained, as illustrated in Figure 7. Figure 7 shows that the creative thinking scores of the pre-service science teachers ( $N = 57$ ,  $M = 27.37$ ,  $SD = 15.181$ ) were normally distributed. This result indicates that the test items employed were effective in discriminating among students with differing levels of creative thinking skills. The bell-shaped distribution further suggests the presence of pre-service science teachers across high, moderate, and low creative thinking levels.

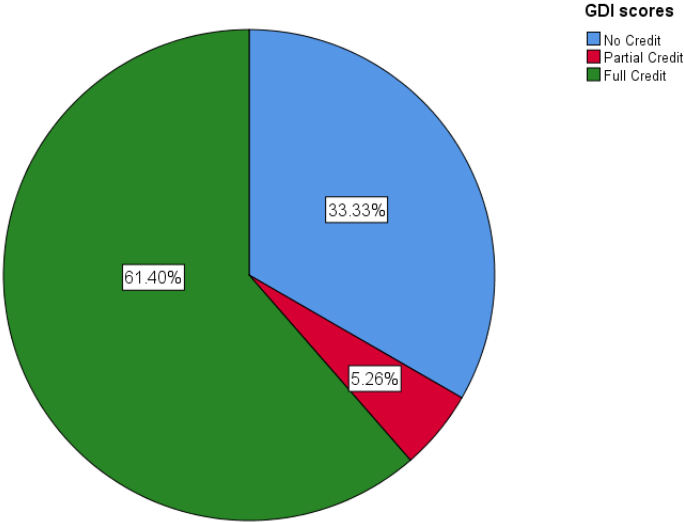


Figure 4. Coding results for GDI by pre-service science teacher

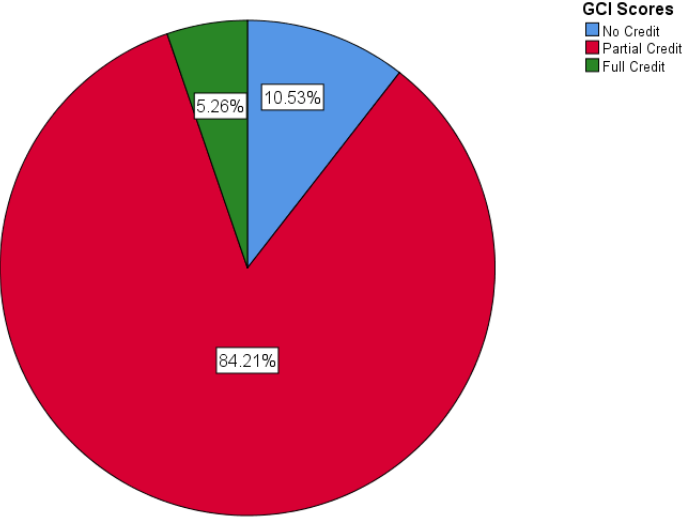


Figure 5. Coding results for GCI by pre-service science teacher

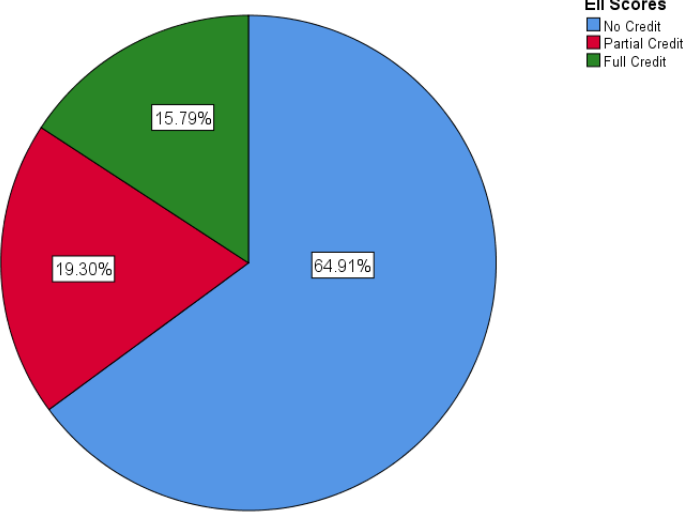


Figure 6. Coding results for EII by pre-service science teacher

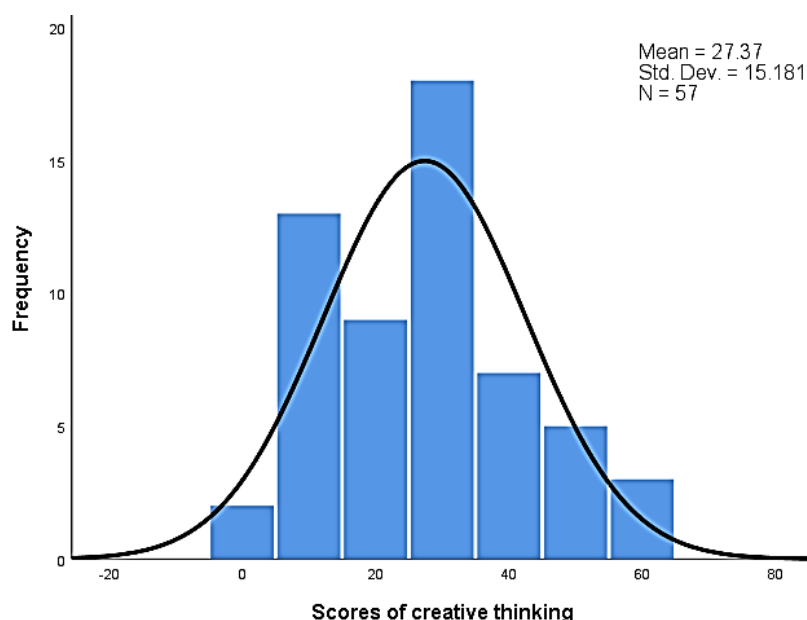


Figure 7. Results of creative thinking score

Statistical calculations of frequencies and percentages for these three categories are presented in Table 4. As shown in Table 4, only a small proportion of pre-service science teachers demonstrated high creative thinking (14%), whereas the majority were classified within the moderate and low creative thinking categories. These results provide a clear depiction of the creative thinking profile of pre-service science teachers based on the PISA 2022 framework.

Table 4. Frequencies and percentage of creative thinking based on its category

Category of Creative Thinking	Frequency	Percent (%)
Low	24	42.1
Moderate	25	43.9
High	8	14.0
Total	57	100.0

### 3.3. Results of The Discriminant Analysis

Discriminant analysis was conducted to examine the ability of the three creative thinking competency domains, Generate Diverse Ideas (GDI), Generate Creative Ideas (GCI), and Evaluate and Improve Ideas (EII), to differentiate among low, moderate, and high creative thinking categories. A total of 57 respondents were included in the analysis, and all data met the required assumptions for analysis, with no missing values detected. The tests of equality of group means indicated that all three predictor (independent) variables differed significantly across the dependent variable (creative thinking categories). Specifically, GDI (Wilks'  $\Lambda = 0.248$ ,  $F = 81.737$ ,  $p < 0.001$ ), GCI (Wilks'  $\Lambda = 0.768$ ,  $F = 8.143$ ,  $p = 0.001$ ), and EII (Wilks'  $\Lambda = 0.344$ ,  $F = 51.482$ ,  $p < 0.001$ ) were each statistically significant in distinguishing between groups, thereby justifying the inclusion of all variables in the discriminant model.

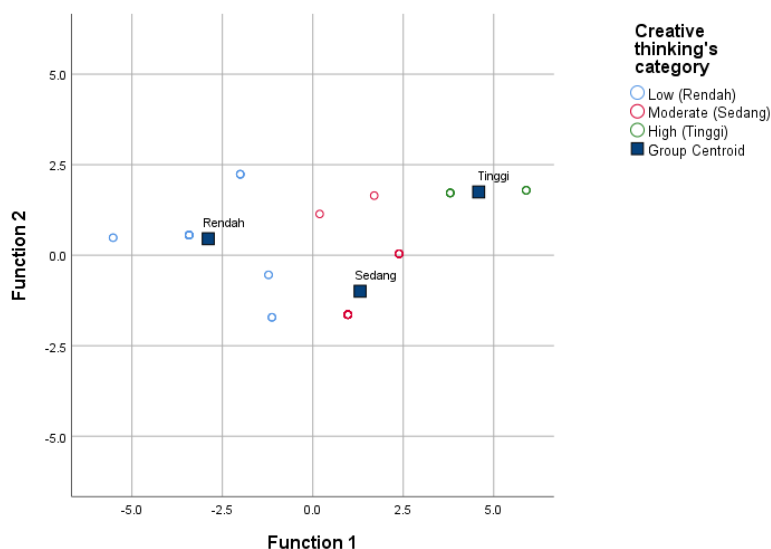


Figure 8. Grup of centroid and creative thinking category based on discriminant function

Based Figure 8, the Box's M test yielded a significant result (Box's M = 50.901,  $p < 0.001$ ), indicating differences in covariance matrices across groups. Although the assumption of homogeneity of covariance was not fully satisfied, the analysis could still be carried out with careful and well-considered interpretation, as discriminant analysis is relatively robust to violations of this assumption, particularly with moderate sample sizes (Denis, 2019). The analysis produced two significant discriminant functions. The first discriminant function had an eigenvalue of 7.617 and accounted for 88.4% of the total variance, with a canonical correlation of 0.94, indicating very strong discriminative power. The second function had an eigenvalue of 1.003 and explained an additional 11.6% of the variance, with a canonical correlation of 0.708. Furthermore, Wilks' Lambda tests demonstrated that both functions were significant both simultaneously ( $\Lambda = 0.058$ ,  $\chi^2 = 150.961$ ,  $p < 0.001$ ) and individually ( $\Lambda = 0.499$ ,  $\chi^2 = 36.811$ ,  $p < 0.001$ ).

Based on the structure matrix, the first discriminant function was most strongly influenced by the GDI (0.582) and EII (0.395) competencies, compared to GCI (0.184), and therefore can be interpreted as a dimension representing the ability to generate and develop ideas. The second discriminant function was dominated by the EII competency (0.848), reflecting more specific evaluative and idea refinement abilities. Group centroid values further indicated clear separation among creative thinking categories. The low creative thinking group exhibited a negative centroid value (-2.890), whereas the moderate and high groups displayed increasingly positive centroid values (+1.307 and +4.585, respectively). This pattern suggests that higher discriminant function scores are associated with higher creative thinking categories, as illustrated in Figure 8.

Finally, classification results demonstrated that the discriminant functions were able to classify respondents into creative thinking categories with a high level of accuracy (94.7%). In addition, cross-validated classification using the leave-one-out method showed a relatively consistent classification pattern (93.0%), indicating that the model possesses good stability and predictive capability and is not overly dependent on a specific sample. It should be noted that discriminant analysis in this study was not used to predict creative thinking scores, but rather to predict group membership. Based on the overall discriminant analysis results, the GDI and EII competencies can be considered the primary predictors of individuals' membership in creative thinking categories, as they exert the strongest influence on the discriminant functions.

### 3.4. Discussion

Evidence from other relevant studies indicates that the creativity and creative thinking skills of pre-service teachers in science, across various universities in several provinces, have been a cause for concern over the past five years. For example, at East Java, Siswati (2024) reported that the initial creative thinking levels of pre-service biology teachers, as measured through a pre-test, fell within the moderate category (61.8) (Siswati & Hariyadi, 2024). Through a pre-experimental research design, creative thinking scores can be improved by implementing the Reading, Finding, Discussing, and Talking (RFDT) approach grounded in Technological Pedagogical Content Knowledge (TPACK). Similarly, Nurita et al. (2024) reported that the baseline creativity of pre-service science teachers prior to instructional intervention was distributed as 39.62% less creative, 52.83% moderately creative, and none of the students reached the creative category (Nurita et al., 2024). Through their research, creative thinking skills can be enhanced through a STEM problem-solving approach. At West Nusa Tenggara (NTB), Susilawati et al. (2021) identified that the initial creativity levels of pre-service physics teachers had an average score of approximately 30 and were classified as less creative (Susilawati et al., 2022). By implementing an inquiry-based learning model supported by PhET interactive simulations, the average creative thinking score of pre-service physics teachers increased to 70. Also at East Nusa Tenggara (NTT), Kerans et al. (2025) found that the creative thinking skills of pre-service biology teachers were categorized as low (Kerans et al., 2024). Then, by developing an authentic inquiry project-based practicum instrument on their local wisdom, the creative thinking skills of pre-service biology teachers was increased. Comparable findings were also reported at Banten, where Utami et al. (2021) found that the creative-critical thinking styles of pre-service physics teachers remained low prior to the implementation of instructional interventions, and it can be increased by STEM learning (Utami et al., 2021). Likewise, at South Kalimantan, Hartini et al. (2021) reported that the creative thinking skills of pre-service physics teachers fell within the not creative category (Hartini et al., 2021). They found that pre-service physics teachers were struggle in generating diverse ideas to find the solution.

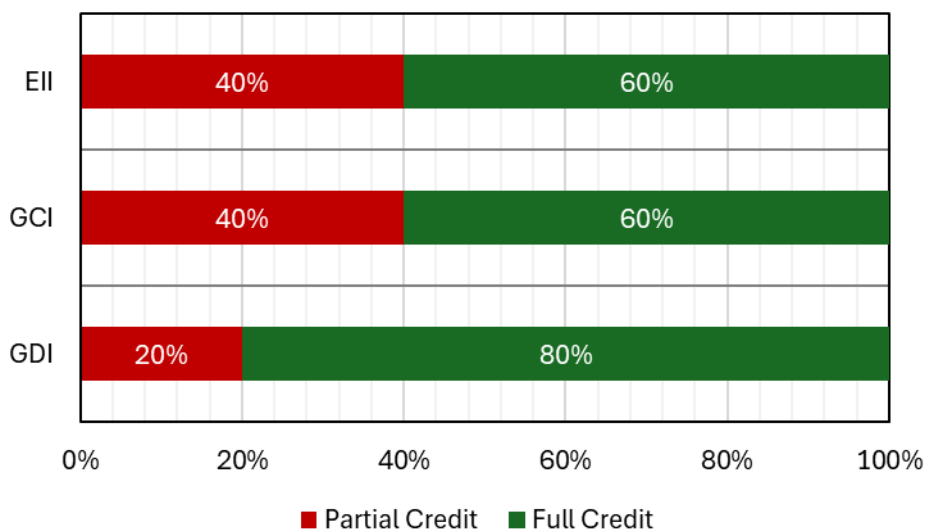


Figure 9. Coding result of GDI, GCI, & EII by doctoral students

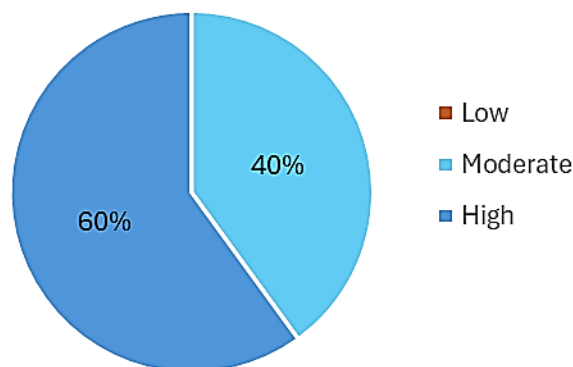


Figure 10. Doctoral student's category of creative thinking

Based Figure 10, in response to the results obtained from the pre-service science teachers (i.e., undergraduate students) described above, we conducted an additional analysis by using the same items of the PISA creative thinking test with 5 doctoral students in science education who had never attempted these questions before descriptively. The coding results for the creative thinking indicators (GDI, GCI, and EII) are presented in Figure 9. As illustrated in Figure 9, for the GDI indicator, the responses of 1 out of 5 doctoral students (20%) were coded as partial credit, while 4 out of 5 students (80%) obtained full credit. Please note that no one has received no credit answer in coding process. In contrast, for the GCI and EII indicators, 2 out of 5 students (40%) received partial credit, whereas 3 out of 5 students (60%) achieved full credit. The lowest percentage of partial credit was observed for the GDI indicator, suggesting that this item was the least difficult. Consequently, the majority of students were able to answer the question successfully and obtain full credit. However, for the more challenging items represented by the GCI and EII indicators, the proportion of partial credit responses doubled. This finding indicates that, based on the quantitative data, even doctoral-level students experienced a noticeable degree of difficulty when responding to the PISA creative thinking assessment items.

The distribution of doctoral students' creative thinking categories is presented in Figure 10. The figure shows that 40% of the doctoral students fall into the moderate category, while 60% are classified as high. This indicates that only 3 of 5 students demonstrated a high level of creative thinking and were able to respond effectively to the PISA Creative Thinking test items, whereas the remaining students experienced difficulties in answering these questions. To further confirm this finding, open brief interviews (with face to face method) were conducted with the doctoral students. This interview aims to give insights regarding the challenges they encountered when completing the PISA Creative Thinking tasks qualitatively and their perspectives on whether Indonesian students would be able to answer such questions effectively. According to the doctoral students, the creative thinking tasks were relatively difficult because they included abstract visual stimuli and required respondents to demonstrate clear distinctions among the ideas they generated. In addition, the difficulty of these tasks lies in how respondents imagine the situation presented in the problem and subsequently conceptualize their responses. This process is closely related to an individual's ability to translate internal ideas into written explanations. In this sense, the ability to communicate ideas becomes a crucial component of creative thinking. Furthermore, the doctoral students noted that the creative thinking tasks were particularly challenging because the problems are situated within the context of little-C creativity, which requires time for reflection as well as deeper cognitive engagement to formulate responses.

When asked whether Indonesian students would be able to answer the PISA Creative Thinking assessment items successfully, all doctoral students expressed a pessimistic view. This pessimism was largely based on their own direct experience after attempting the tasks themselves. To corroborate these qualitative findings, the researchers referred to the results of Indonesian students' creative thinking performance in PISA 2022, which remain substantially below the OECD average (33 points) and fall within the low category (19 points) (OECD, 2023a). For comparison, the creative thinking scores of students classified in the low category in countries such as Singapore, South Korea, Canada, Australia, and New Zealand remain higher than the scores of students categorized as high in countries such as Morocco, Philippines, Dominican Republic, Uzbekistan, and Albania. Collectively, these findings suggest that the actual condition of pre-service teachers' creative thinking skills is substantially below the ideal standards outlined in the Permendiknas No. 16 of 2007. This discrepancy highlights a significant gap in creative thinking competencies among pre-service teachers across diverse disciplinary fields. Consequently, further research is warranted in the form of innovative instructional designs, learning models, instructional media, teaching materials, and assessment strategies to enhance the creative thinking skills of pre-service science teachers and helps students creative thinking in Indonesia.

Experts have various opinions regarding obstacles in the development of creative thinking. They emphasize that educator's understanding of creativity is a fundamental prerequisite for teaching it effectively (Beghetto & Kaufman, 2014). This aligns with findings indicating that many teachers still lack a clear conceptual understanding of creativity. In addition, another study shows that teachers' conceptions of creativity are often inconsistent with theoretical perspectives, reinforcing the evidence of confusion identified in this study (Andiliou & Murphy, 2010). In the context of students, it highlights the importance of possibility thinking, which emphasizes deep exploration of ideas. However, the limited time identified in this study constrains such exploratory processes. Furthermore, creativity in science involves the ability to construct hypotheses and explanations (Taber, 2017). The finding that students struggle to think deeply suggests that this capacity has not yet been optimally developed. From an environmental perspective, the 5A framework underscores the importance of affordances, or environmental support (Glăveanu, 2013). This is consistent with the finding that school and classroom environments often do not adequately support student creativity. Moreover, it indicates that education systems oriented toward standards and assessment may inhibit creativity, a condition reflected in the pressures of grading and dense curricula experienced by both teachers and students. Furthermore, it argues that although numerous theories of creativity exist, their practical implementation remains limited in classroom settings, reinforcing the finding that implementation barriers are still highly evident (Sternberg & Karami, 2024). The lack of professional training also emerges as a critical issue which aligns with the finding that teachers are insufficiently prepared to teach creativity (Lucas et al., 2012). Overall, these theoretical perspectives suggest that the barriers in creative thinking related in this study are systemic and multidimensional.

#### **4. CONCLUSION**

Creative thinking is a critical skill that is not only essential in the twenty-first century but also constitutes a core component of teachers' pedagogical and professional competencies.

Accordingly, this study aimed to examine the creative thinking profiles of pre-service science teachers using three PISA 2022 creative thinking test items administered to 61 participants. Rasch model analysis indicated high item reliability but low person reliability, likely due to the sample number of the test as a research limitation. However, all items still remained valid and adequately represented each indicator of creative thinking. Descriptive results showed a normal distribution of scores, with most participants categorized at moderate and low levels, while discriminant analysis identified GDI and EII as key predictors of creative thinking categories. Overall, these findings provide empirical support for the use of the PISA framework in profiling pre-service teachers' creative thinking and suggest the need for better alignment in teacher education.

## ACKNOWLEDGEMENTS

The authors would like to express their gratitude to Beasiswa Pendidikan Indonesia (BPI) or Indonesia Education Scholarship, Pusat Pembiayaan dan Asesmen Pendidikan Tinggi (PPAPT) or Center for Higher Education Funding and Assessment, under The Ministry of Higher Education, Science and Technology (Kemendikti Saintek) and Lembaga Pengelola Dana Pendidikan (LPDP) or Indonesian Endowment Fund for Education for funding their doctorate degree.

## REFERENCES

- Agustin, N. W., Sarwanto, S., & Supriyanto, A. (2021). Problem Based Learning on Newton's Law: Can It Improve Student Creativity? *Jurnal Pendidikan Sains Indonesia*, 9(4), 528–539. <https://doi.org/10.24815/jpsi.v9i4.20974>
- Alabbasi, A. M. A., Paek, S. H., Kim, D., & Cramond, B. (2022). What do educators need to know about the Torrance Tests of Creative Thinking: A comprehensive review. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.1000385>
- Albers, A., Bastian, A., Düser, T., Voelk, T. A., & Kuebler, M. (2025). Defining technical creativity: iterative development of a shared understanding. *Proceedings of the Design Society*, 5, 1131–1140. <https://doi.org/10.1017/PDS.2025.10127>
- Andiliou, A., & Murphy, P. K. (2010). Examining variations among researchers' and teachers' conceptualizations of creativity: A review and synthesis of contemporary research. *Educational Research Review*, 5(3), 201–219. <https://doi.org/10.1016/J.EDUREV.2010.07.003>
- Andrich, D., & Marais, I. (2019). *A Course in Rasch Measurement Theory Measuring in the Educational, Social and Health Sciences*. Springer Nature. <https://doi.org/https://doi.org/10.1007/978-981-13-7496-8>
- Beghetto, R. A., & Kaufman, J. C. (2014). Classroom contexts for creativity. *High Ability Studies*, 25(1), 53–69. <https://doi.org/10.1080/13598139.2014.905247>
- Chugh, D., & Tiwari, V. (2024). *Assessing the Effect of Introducing Design Education on Middle-Year Students' Creative, Critical, and Problem-Solving Skills*. 417–426. [https://doi.org/10.1007/978-981-97-9206-1\\_35](https://doi.org/10.1007/978-981-97-9206-1_35)
- Cohen, L., Manion, L., & Morrison, K. (2018). *Research Methods in Education* (8th ed.). Routledge, Taylor & Francis Group.
- Denis, D. J. (2019). *SPSS data analysis for univariate, bivariate, and multivariate statistics*. Wiley.

- Glăveanu, V. P. (2013). Rewriting the language of creativity: The five A's framework. *Review of General Psychology*, 17(1), 69–81. <https://doi.org/10.1037/A0029528;PAGE:STRING:ARTICLE/CHAPTER>
- Hartini, S., Liliyasi, S., Sinaga, P., & Abdullah, A. G. (2021). Creative thinking skill for pre-service physics teacher: An investigation in the topics of radioactivity. *Journal of Physics: Conference Series*, 012001. <https://doi.org/10.1088/1742-6596/1760/1/012001>
- Huang, C.-F., & Wang, K.-C. (2019). Comparative Analysis of Different Creativity Tests for the Prediction of Students' Scientific Creativity. *Creativity Research Journal*, 31(4), 443–447. <https://doi.org/10.1080/10400419.2019.1684116>
- Kerans, G., Sanjaya, Y., Liliyasi, L., Pamungkas, J., & Ghanggo Ate, Y. (2024). Effect of Substrate and Water on Cultivation of Sumba seaworm (nyale) and experimental practicum design for improving critical and creative thinking skills of prospective science teacher in biology and Supporting Sustainable Development Goals (SDGs). *ASEAN Journal of Science and Engineering*, 4(3), 383–404. <https://ejournal.kjpupi.id/index.php/ajse/article/view/430>
- Kim, K. H. (2017). The Torrance Tests of Creative Thinking - Figural or Verbal: Which One Should We Use? *Creativity. Theories – Research - Applications*, 4(2), 302–321. <https://doi.org/10.1515/ctra-2017-0015>
- King, B. M., Rosopa, P., & Minium, E. W. (2018). *Statistical reasoning in the behavioral sciences* (7th Edition). John Wiley & Sons, Inc.
- Lucas, B., Claxton, G., & Spencer, E. (2012). *Progression in Student Creativity in School: First Steps Towards New Forms of Formative Assessments*. <https://doi.org/10.1787/5k4dp59msdwk-en>
- McLure, F., Won, M., & Treagust, D. F. (2024). Science Teachers' Understanding of Creative Thinking and How to Foster It as Mandated by the Australian Curriculum. *Journal of Science Teacher Education*, 35(5), 524–543. <https://doi.org/10.1080/1046560X.2024.2313882>
- Nurita, T., Yuliati, L., Mahdiannur, M. A., Ilhami, F. B., Fauziah, A. N. M., Hendratmoko, A. F., & Puspitarini, S. (2024). Increasing Pre-service Science Teacher Creativity Through STEM Problem-Solving. *Jurnal Penelitian Pendidikan IPA*, 10(1), 72–79. <https://doi.org/https://doi.org/10.29303/jppipa.v10i1.6335>
- OECD. (2023a). *PISA 2022 Results Creative Minds, Creative Schools*. OECD Publishing.
- OECD. (2023b). *PISA 2022 Results (Volume I): The State of Learning and Equity in Education: I*. OECD Publishing. <https://doi.org/10.1787/53f23881-en>
- OECD, & UNICEF. (2021). Education in Eastern Europe and Central Asia: Findings from PISA. In *PISA* (pp. 1–96). OECD Publishing. [https://www.oecd-ilibrary.org/education/education-in-eastern-europe-and-central-asia\\_ebeeb179-en](https://www.oecd-ilibrary.org/education/education-in-eastern-europe-and-central-asia_ebeeb179-en)
- Permendiknas RI tentang Standar Kualifikasi Akademik dan Kompetensi Guru, Pub. L. 16, Biro Hukum dan Organisasi 1 (2007).
- Ramly, S. N. F., Ahmad, N. J., & Yakob, N. (2022). Development, validity, and reliability of chemistry scientific creativity test for pre-university students. *International Journal of Science Education*, 44(14), 1–16. <https://doi.org/10.1080/09500693.2022.2116298>
- Rao, H., Puranam, P., & Singh, J. (2022). Does design thinking training increase creativity? Results from a field experiment with middle-school students. *Innovation: Organization and Management*, 24(2), 315–332. <https://doi.org/10.1080/14479338.2021.1897468>

- Rohman, M. H., Marwoto, P., Nugroho, S. E., & Supriyadi, S. (2024). Effectiveness of Ethnoecological-STEM Project-Based Learning Model to Improve Critical Thinking Skills, Creativity, and Science Concept Mastery. *International Journal of Cognitive Research in Science, Engineering and Education*, 12(3), 521–534. <https://doi.org/10.23947/2334-8496-2024-12-3-521-534>
- Siswati, B. H., & Hariyadi, S. (2024). Effectiveness of RFDT learning based on TPACK framework in improving the critical and creative thinking abilities of prospective biology teacher students. *BIO-INOVED: Jurnal Biologi-Inovasi Pendidikan*, 6(3). <https://ppjp.ulm.ac.id/journal/index.php/bino/article/view/19563>
- Sternberg, R. J., & Karami, S. (2024). *Transformational Creativity: Learning for a Better Future*. Palgrave Macmillan.
- Susilawati, S., Doyan, A., Mulyadi, L., Abo, C. P., & Pineda, C. I. S. (2022). The Effectiveness of Modern Physics Learning Tools using the PhET virtual media assisted inquiry model in improving cognitive learning outcomes, science process skills, and scientific creativity of prospective teacher students. *Jurnal Penelitian Pendidikan IPA*, 8(1). <https://jppipa.unram.ac.id/index.php/jppipa/article/view/1304>
- Taber, K. S. (2017). Knowledge, beliefs and pedagogy: how the nature of science should inform the aims of science education (and not just when teaching evolution). *Cultural Studies of Science Education*, 12(1), 81–91. <https://doi.org/10.1007/S11422-016-9750-8>
- Utami, I. S., Vitasari, M., Langitasari, I., & Mulyati, D. (2021). The implementation of STEM learning on creative-critical thinking styles (study on pre-service physics teacher). *Proceedings of The 2nd Science and Mathematics International Conference (SMIC 2020)*. [https://doi.org/10.1063/5.0041991/13150024/030029\\_1\\_online](https://doi.org/10.1063/5.0041991/13150024/030029_1_online)
- W. Creswell, J., & David Creswell, J. (2018). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches* (5th ed.). SAGE Publications, Inc.
- Yuan, Y., Humphrey, S. E., & van Knippenberg, D. (2022). From individual creativity to team creativity: A meta-analytic test of task moderators. *Journal of Occupational and Organizational Psychology*, 95(2), 358–404. <https://doi.org/10.1111/JOOP.12380>