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The Dynamics of Scientific Attitudes in Fostering Creativity: A Study on Secondary School

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Abstract

Indonesian students' low science literacy underscores the need to foster a scientific attitude and creativity for 21st-century learning. This study examined the association between scientific attitudes and creativity among 112 grade 8 students from five secondary schools in Ponorogo Regency using quantitative methodologies and a cross-sectional design. Data were collected via Google Forms distributed through WhatsApp groups, employing the Scientific Attitude Inventory (SAI II) and a modified Kaufman Domains of Creativity Scale (K-DOCS). Analyses using t-tests, linear regression, and correlation tests revealed that perseverance, environmental sensitivity, and cooperation significantly predict scientific creativity. Furthermore, female students demonstrated higher persistence and environmental sensitivity than male peers. This study highlights the value of adaptable and context-based teaching strategies, such as project-based learning, to foster student's broad development in their scientific mindsets and inventiveness.

Keywords: Scientific attitude, scientific creativity, perseverance

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INTRODUCTION

In an era of rapid technological advancement, it is vital to master scientific thinking abilities, particularly scientific attitudes and inventiveness. This is consistent with the demands of the workplace, where soft skills such as critical thinking, adaptability, and creativity are the primary indicators of increased employability (Poláková et al., 2023). Scientific creativity focuses on the capacity to produce concepts and creative solutions grounded in a thorough comprehension of science (Sun et al., 2020; Zainuddin et al., 2020), which is not only essential for academic success but also for addressing global challenges such as climate change, public health crises, and technological innovation.

In Indonesia, the development of scientific attitudes and scientific creativity is crucial, given the findings from the Program for International Student Assessment (PISA) 2022, which showed that Indonesian students scored an average of 383 on science literacy, 102 points adrift of the global average score of 485 (Kemdikbudristek, 2023). This gap highlights the need for a renewed focus on fostering critical and creative thinking skills in science education. While countries like Finland and Singapore have successfully improved students' science literacy through approaches that emphasise exploration, experimentation, and data-driven discussions (OECD, 2023), Indonesia’s education system still heavily relies on rote memorisation. The recently implemented ‘Merdeka Curriculum offers a promising framework, emphasising not only conceptual understanding but also critical and creative problem-solving in science education (Pertiwi et al., 2023). However, the practical implementation of these concepts requires further study to maximise their impact on student's scientific attitudes and creativity.

Theoretical frameworks from cognitive psychology and constructivism provide valuable insights into the relationship between scientific attitudes and scientific creativity. According to cognitive psychology theory (Kenett et al., 2023; Hunaepi et al., 2024), scientific attitudes like curiosity support an individual's ability to process information flexibly, which encourages creative ideas. In this case, curiosity not only increases knowledge but also stimulates individuals to explore new solutions based on existing evidence. Meanwhile, constructivist theory emphasises the importance of actively interacting with the environment to get a deeper understanding. Experiential learning increases the meaning of learning by allowing students to apply knowledge in real life, promotes comprehensive understanding and has the potential to shape creativity in scientific problem-solving (Aswita, 2020). Teachers who are able to create a learning environment based on exploration and experimentation can strengthen students' scientific attitudes, which in turn can enhance their scientific creativity. This is in line with recent research by (Xu et al., 2024), which showed that active inquiry-based learning involving experiments improved students' creative thinking skills in science.

Despite these theoretical insights, research on the relationship between scientific attitudes and creativity remains limited, particularly in the context of Indonesian secondary schools. Most studies have focused on either scientific attitudes or creativity as separate constructs. For instance, scientific attitudes are often linked to improved critical thinking skills, which aid in evidence-based decision-making (Halini et al., 2023), while scientific creativity is associated with generating innovative solutions to problems (Fernandez et al., 2024). However, few studies have explored how specific scientific attitudes, such as curiosity, perseverance, and openness to evidence, influence creativity. Additionally, the role of gender in shaping these relationships has been largely overlooked despite evidence suggesting that gender differences may influence students' engagement with science (Löffler & Greitemeyer, 2021). Understanding these dynamics could provide valuable insights for designing inclusive educational strategies that cater to the diverse needs of students.

Against this background, this study explores the relationship between scientific attitudes and scientific creativity among secondary school students in Indonesia. It examines whether traits like curiosity and openness to evidence correlate with scientific creativity and whether gender differences play a role. The findings aim to enrich science education literature and provide practical recommendations for enhancing students' scientific literacy and global competitiveness.

METHODS

The research employed a quantitative cross-sectional design to analyse the relationship between scientific attitudes and creativity at a single point in time using numerical data. The research was conducted over two months and consisted of the following stages. The population of this study consisted of all eighth-grade students in Ponorogo Regency who were actively engaged in science learning during the academic year 2024/2025. The sampling framework was based on a list of secondary schools obtained from open sources and direct communication with school administrators. Participant distribution varied across the five schools due to logistical constraints and differing levels of cooperation, with one school contributing 80 students and others around

15. Despite this limitation, the sample size of 112 is considered adequate for exploratory research and is consistent with similar studies in the fields (Ahmed, 2024). The selected students were at a developmental stage where they possessed a basic understanding of science while still cultivating their critical and creative thinking skills, making them ideal subjects for this study. Moreover, they had recently studied the relevant science topics covered in the questionnaire, ensuring familiarity with the content.

Students' scientific attitudes were measured using the Scientific Attitude Inventory II (SAI II), which was translation, contextualisation, and pilot testing. The 14-item instrument measures seven indicators: curiosity, prioritising data or facts, critical thinking, liking to discover and create, being open-minded and willing to work together, being sensitive to the surrounding environment, and perseverance. Each indicator is represented by two items on a 5-point Likert scale. Reliability analysis showed good internal consistency (Cronbach's alpha = 0.718). Validity testing using Pearson's correlation confirmed that all indicators were valid, with inter-item correlations exceeding the r-table threshold at a 0.05 significance level.

Students' scientific creativity was measured using an adapted version of the Kaufman Creativity Domain Scale (K-DOCS), as well as translation, contextualisation, and pilot testing. The 14 items measure seven dimensions: determining scientific problems, making scientific hypotheses, designing scientific experiments, conducting scientific data analysis, developing scientific products, using scientific imagination, and transforming scientific problems into solutions. Two items represented each indicator, and responses were recorded on a 5-point Likert scale. The instrument demonstrated excellent reliability (Cronbach's alpha = 0.773). Validity testing using Pearson's correlation confirmed all indicators were valid, with inter-item correlations surpassing the r-table threshold at a 0.05 significance level. Sample items are provided in Table 1.

Data were collected through an online questionnaire distributed via Google Forms to student WhatsApp groups. Gender data were also collected for potential subgroup analysis. To ensure data quality, several measures were taken. In some schools, the questionnaire was administered under the direct supervision of researchers, while in others, teachers facilitated the process to ensure independent responses. Students received clear instructions on the study's purpose, the importance of honest responses, and data confidentiality. Responses were reviewed for completeness and adherence to instructions, yielding 112 valid responses.

The data were analysed using both parametric and nonparametric statistical techniques, depending on the nature of the data and the research questions. Spearman's rank correlation was used to examine the relationships between scientific attitudes and scientific creativity, as it is suitable for ordinal data from a Likert scale and does not require normality assumption.

Linear regression was used to evaluate the influence of scientific attitudes on scientific creativity. Although the data were ordinal, the average scores for each indicator were treated as continuous variables, a common approach in social science research (Robitzsch, 2020). However, the results were interpreted with caution, considering the ordinal nature of the original data.

Independent t-tests were conducted to assess gender differences in scientific attitudes and creativity. Similar to the regression approach, the indicator scores were treated as continuous, enabling parametric testing. While previous research supports this method for Likert-scale data, the findings were interpreted with caution (Robitzsch, 2020).

Additionally, SEM-PLS was applied to analyse the causal relationships between scientific attitudes and creativity, given its suitability for analysing latent constructs. The measurement model was first evaluated for validity and reliability, with convergent validity confirmed through AVE values above 0.50 and discriminant validity assessed using the

Fornell-Larcker Criterion. Indicators with outer loadings above 0.70 were retained, while those between 0.40 and 0.70 were considered for retention only if they improved composite reliability or AVE (Hair et al., 2021). The structural model was then tested using path coefficients, with significance determined via bootstrapping (5,000 resamples), and a p-value < 0.05 was considered statistically significant.

Table 1. Sample Scale Items

Scale	Indicator	Sample item
SAI II	Curiosity	If you want to know how food affects digestion, what would you do?
	Prioritising data	You will find an article about fast eating and digestive problems. What should you do to prove it?
	Critical thinking	You will find different information about air pollution and lung disease. What should you do?
	Enjoying discovery and creativity	You want to make an interactive heart model. What should you do?
	Open-mindedness and teamwork	Some of your friends disagree with the group's idea of the project. What is your best attitude?
	Sensitivity to the environment	How do you respond to burning garbage in your environment?
	Perseverance	You have difficulty understanding the mechanism of enzymes. What should you do?
K-DOCS	Determine the problem	How do we understand the difference in blood pressure in two people with similar physical activity?
	Make a hypothesis	What is the hypothesis about the relationship between salt consumption and kidney workload?
	Designing experiments	List of References
	Analyse data	What is the first step to test the effect of physical activity on the amount of oxygen inhaled?
	Develop scientific products	How do we compare data on water consumption and urine volume of experiment participants?
	Scientific imagination	How can an innovative learning aid for the circulatory system be created?
	Transformation of scientific problems	What are the concrete steps to reduce the impact of air pollution on health?

Table 2. Interpretation Guidelines for Correlation Coefficients

No	Coefficient Interval	Correlation Range
1	0.000 - 0.199	Very weak
2	0.200 - 0.399	Weak
3	0.400 - 0.599	Moderate
4	0.600 - 0.799	Strong
5	0.800 - 1.000	Very Strong

RESULTS & DISCUSSION

Scientific attitude is defined as the tendency to consistently apply scientific approaches (Sukarni et al., 2020), and it serves as the foundation for the development of a more advanced scientific mindset. Scientific attitudes represent a person's behaviour when engaged in scientific activities that demand patience and methodical strategies to solve problems (Amaliyah et al., 2024). Meanwhile, scientific creativity refers to students' ability

to formulate unique ideas and solutions using scientific reasoning. After respondents had completed the questionnaire, the data was evaluated using correlation analysis to evaluate the strength of the correlation between the two variables. The findings of the analysis of scientific attitudes and their influence on students' scientific creativity may be seen from each indicator item of scientific attitudes and their influence on students' scientific creativity using the following hypothesis:
H_0: There is no correlation between scientific views and pupils' scientific creativity.
H_1: There is a link between scientific attitudes and pupils' scientific innovation.
Criteria: Reject the null hypothesis (H_0) if the p-value is significant (< 0.05).
The results of this correlation analysis are presented in Table 3.

Table 3. Correlation Between Scientific Attitude Indicators and Scientific Creativity

Indicator	**Scientific creativity**	
	Pearson Correlation	**Sig. (2-tailed)**
Curiosity	0.183	0.053
Prioritising data or facts	0.224	0.018
Critical thinking	0.212	0.025
Enjoying discovery and creativity	0.319	0.001
Open-mindedness and teamwork	0.641	0.000
Sensitivity to the environment	0.647	0.000
Perseverance	0.691	0.000

Table 3 indicates that the composite score showed a moderate positive correlation with scientific creativity ($r = 0.58$, $p < 0.001$), indicating that students with stronger scientific attitudes tend to exhibit higher levels of creativity. Notably, perseverance (0.691, $p < 0.001$), sensitivity to the environment ($r = 0.647$, $p < 0.001$), and open-mindedness and teamwork ($r = 0,641$, $p < 0.001$) are strongly linked to creativity. Perseverance helps students delve deeper into novel concepts (Wu & Koutstaal, 2022). Sensitivity to the environment, open-mindedness, and teamwork also confirmed the importance of collaboration-based learning and contextual issues. Sensitivity to the environment allows students to integrate direct observation into the creative process, which is the foundation for critical and innovative thinking (Perdana et al., 2020).

In contrast, curiosity showed a weak correlation ($r = 0.183$, $p = 0.053$) and was not significant, which is surprising given that curiosity is often associated with creativity. As Zhang et al. (2024) noted, curiosity alone may not be sufficient to drive creativity outcomes without intrinsic motivation and opportunities for hands-on exploration. Contextual factors may also influence curiosity's weak correlation with creativity, such as certain tendencies in the education culture in Indonesia. As suggested by recent research, the learning process benefits greatly from a diverse range of resources and interactive methods, such as blended learning and experiential learning (Munna & Kalam, 2021). However, the traditional emphasis on structured learning may still dominate in some educational contexts, potentially limiting opportunities for open-ended exploration or imaginative thinking. While structured approaches help build foundational skills, they might not fully support the kind of intellectual risks or unconventional problem-solving that curiosity can foster. The weak correlation may reflect the influence of other variables, such as self-efficacy of prior knowledge, which were not measured in this study.

Following conducting a correlation test on 112 students, a regression analysis was performed on a subset of 84 students to examine how scientific attitudes predict scientific creativity. Since the data were ordinal, normality testing was unnecessary for Spearman's correlation. However, residual analysis confirmed normality ($p > 0.05$) for regression and t-tests, ensuring valid parametric testing. The study tested the following hypotheses:
H_0: Scientific attitudes do not significantly influence students' scientific creativity
H_1: Scientific attitudes significantly influence students' scientific creativity.
Testing criteria: The model is considered appropriate if the R Square value shows a high enough percentage of variability in students' scientific creativity that scientific attitude indicators can explain and if the Adjusted R Square value shows consistency of results despite adjustments to the number of independent variables—the regression test results presented in Table 4.

Table 4. Influence of Scientific Attitude Indicators on Scientific Creativity

Model Summary			
Indicator	*R Square*	Adjusted R Square	Std. Error of the Estimate
Open-mindedness and teamwork	0.346	0.338	7.30704
Sensitivity to the environment	0.314	0.306	7.48342
Perseverance	0.397	0.390	7.01530

Table 4 presents the results of the regression analysis, focusing on the influence of individual scientific attitude indicators on scientific creativity. The regression model included perseverance, open-mindedness, teamwork, and environmental sensitivity as predictors, as these indicators showed the strongest correlations with creativity in the preliminary analysis. Perseverance indicator has the greatest influence, with an R Square value of 39.7%. This indicates that almost 40% of the variability in scientific creativity can be explained by student perseverance. These results are in line with the findings of Dewi et al. (2022), who discovered that tenacity is an important aspect in fueling the creative process since it inspires people to keep working to overcome hurdles. Open-mindedness and teamwork cooperation were also important predictors of scientific creativity, accounting for 34.6% and 31.4% of the variance, respectively. This is consistent with previous findings that open-mindedness broadens perspectives and ideas (Jung & Lee, 2022), while cooperativeness enhances creativity through the exchange of ideas within a group (Stolaki et al., 2023). The indicator of being sensitive to the surrounding environment, which explained 31.4% of the variability, demonstrates that students who are sensitive to social and environmental contexts can relate scientific knowledge to current issues, which enhances theirs.

According to the regression study, perseverance has the highest impact on scientific originality, with a R Square value of 39.7%. Interestingly, further investigation revealed that the relevancy of the learning materials had a significant impact on boosting student perseverance. Students demonstrated high perseverance scores in the digestive and excretory systems, for example, since these topics were closely tied to their real-life experiences, such as a good diet, the significance of hydration, and body cleanliness. This link allows students to explore more, solve problems, and find novel solutions. According to Haryanto and Arty (2019), the subject's relevance could enhance students' self-efficacy, pushing them to persevere in the face of obstacles. Students not only understand scientific topics in a learning context that is actually directly helpful but they are also inspired to connect theory and practice, which is a vital stage in developing scientific creativity.

In addition to relevance, the context of this material also strengthens students' positive emotional engagement. When they feel that what they are learning is relevant to their daily lives, satisfaction and enthusiasm increase, which in turn strengthens perseverance in learning. In Wijaya et al. (2022), perseverance is closely related to students' ability to govern their learning process, which includes goal setting, progress monitoring, and evaluation. As a result, a high score on the persistent indicator not only demonstrates students' effort in handling problems but also how they are engaged, which may bridge scientific understanding with practical inventiveness, which is ultimately an important factor in innovation-based learning.

Following the regression analysis, a t-test compares male and female students on three significant scientific attitude indicators: perseverance, open-mindedness, willingness to cooperate, and sensitivity to the environment. This t-test was designed to determine whether there was a significant difference between the two gender groups. Cohen's d was computed to determine the effect magnitude of the difference, with three interpretations: small (d <0.2), medium (d ~0.5), and big (d ~0.8). The t-test and Cohen's d findings for each indication are shown in Table 5.

Table 5. Results of the t-test for differences in indicators

Model Summary									
variable	category	N	Mean	S	df	t	p*	Cohen's d	interpretation
Open-mindedness and teamwork	female	45	8.980	1.62	82	1.90	0.061	0.412	Small effect size
	male	39	8.170	2.26					
Sensitivity to the environment	female	45	8.610	1.89	82	3.59	0.001	0.789	Medium effect size
	male	39	7.020	2.13					
Perseverance	female	45	59.76	8.51	80	2.92	0.004	0.652	Medium effect size
	male	39	54.11	8.83					

The first indication, being open-minded and willing to cooperate, had a higher mean score for females (8.98) than males (8.17). However, the t-test revealed a p-value of 0.061, which is close to the significance level but not enough to declare the difference significance's d (0.412), suggesting a small to moderate impact size. This finding is consistent with the findings of Sepuru et al. (2020), who found that broader social and environmental factors influence collaboration and openness more than gender differences. Although there is a difference in mean scores, the tiny effect size suggests that other factors, such as educational experiences and social support, may have a greater impact on students' openness and collaboration.

Indicator of environmental sensitivity: There was a clearer difference between female (8.61) and male (7.02) pupils, with the t-test generating a very significant p-value (0.001). Cohen's d value of 0.789 shows a medium effect size, implying that this difference has a stronger influence than other indicators. This finding is consistent with previous research suggesting that females are more sensitive to social and environmental issues. For example, Löffler and Greitemeyer (2021) indicate that females are more likely to express empathy and care for social and environmental situations, which may influence how they approach challenges in a scientific setting. These discrepancies highlight the need to take gender into account when developing a curriculum that stresses social and environmental responsibility.

Indicator perseverance revealed a significant difference with a p-value of 0.004 and Cohen's d of 0.652, indicating a modest effect size. Female students (59.76) outperformed males (54.11), demonstrating that females are more persistent when faced with adversities. The differences are slight; they provide insight into how character development in learning environments ought to be customised to account for gender differences in perseverance.

Although certain variables showed significant differences, the impact sizes ranged from small to medium, demonstrating that while gender influences scientific views, the differences are not necessarily huge. Several studies have found that social, cultural, and educational intervention variables have a bigger impact on the formation of scientific attitudes than gender differences (Belova et al., 2024; Mansour, 2024). As a result, the findings of this t-test must be interpreted from a broader perspective, taking into account external influences that influence students' scientific beliefs. This study also emphasises the need for an inclusive and social context-based approach, taking into account the differences in interests between girls who are more sensitive to environmental issues and boys who excel in the area of perseverance, emphasising the importance of equal opportunities for all students.

The initial study utilising the correlation test revealed a positive association between scientific attitudes and scientific creativity, which was supported by the regression analysis, which yielded a significant coefficient. The t-test indicated that scientific views significantly influenced students' scientific inventiveness. Following these findings, the SEM-PLS (Structural Equation Modeling-Partial Least Squares) approach was used to conduct an additional study. SEM-PLS was chosen because of its ability to analyse complex relationships between latent variables that cannot be measured directly, such as scientific attitudes and scientific creativity, as well as the relationship between indicators in each latent variable to provide a more detailed picture of each indicator's influence (Hair et al., 2021). The results of the SEM-PLS analysis are shown in Figure 1 in the form of a path diagram that illustrates the relationship between indicators, dimensions, and latent variables in this study. Scientific creativity as the main latent variable is explained by three dimensions, namely Exploration and Innovation, Critical and Objective, and Collaboration and Care. Each dimension has specific indicators that show their respective contributions to the formation of students' scientific creativity. The path coefficient and outer loading values indicate the strength of each indicator's contribution to the dimensions and dimensions of the main latent variables.

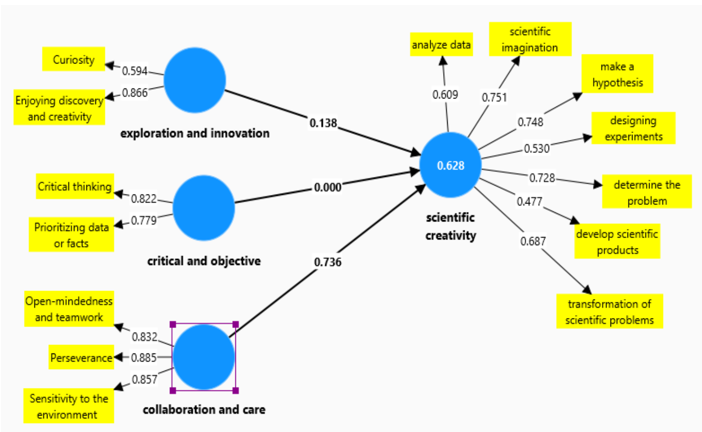

Figure 1. Research Path Diagram

The SEM-PLS analysis revealed that the Collaboration and Concern dimension has the largest contribution to scientific creativity (path coefficient = 0.736. $p < 0.00$), indicating that traits such as teamwork, environmental sensitivity, and perseverance play a dominant role in fostering creativity. This is in line with previous findings in the regression analysis, which showed that indicators of perseverance, open-mindedness, and the ability to work together have a large influence on scientific creativity. This shows that social traits, such as the ability to work together and concern for the environment, are indeed dominant factors influencing scientific creativity, which is also reflected in the high correlation between environmental sensitivity ($r = 0.647$) and the ability to work together ($r = 0.641$). A recent study by Hornstra et al. (2022) confirmed that scientific creativity depends not only on individual skills but also on the individual's ability to work in a team and utilise collective strengths in the group.

On the other hand, the Exploration and Innovation dimension has a lower contribution to scientific creativity (path coefficient value of 0.138, $p = 0.052$), suggesting that while students may have an initial interest in exploring new ideas, this interest alone is not sufficient to drive creative outcomes. As Adi et al. (2023) Noted, curiosity needs to be supported by relevant learning materials and challenges that encourage critical thinking. Interestingly, the Critical and Objective dimensions did not show a significant relationship with creativity (path coefficients = 0.000, $p > 0.05$). This finding suggests that critical thinking may function more as a filter for evaluating existing ideas rather than a driver of new creative solutions. As Indrašienė et al. (2021), critical thinking often strengthens existing ideas but may not directly contribute to the generation of novel concepts. Overall, the results of the SEM-PLS analysis indicate that collaboration and concern are the main elements in the formation of students' scientific creativity, supported by perseverance and open-mindedness, which are very significant factors. Meanwhile, the dimensions of Exploration and Innovation and Critical and Objective require a more integrated learning strategy in order to make a greater contribution to scientific creativity.

However, this study has several limitations that need to be considered. First, the number of samples used was limited to 8th-grade students from five high schools in Ponorogo Regency, so the results of this study cannot be generalised to a wider population. Second, data were collected through online questionnaires, which may affect the accuracy of students' answers due to the lack of direct supervision. Third, despite validity and reliability testing, potential bias in student responses remains. These limitations are a major concern in interpreting the results of the study.

The finding that perseverance has the strongest influence on scientific creativity highlights the importance of fostering resilience and persistence in students. This is particularly relevant in the context of science education, where students often face complex and challenging problems. As Wijaya et al. (2020) noted, perseverance is closely linked to a student's ability to set goals, monitor progress, and evaluate their learning, all of which are essential for creative problem-solving. However, the weak correlation between curiosity and creativity suggests that traditional teaching methods may not fully leverage student's natural curiosity. To address this, educators should consider incorporating inquiry-based learning and project-based learning into the curriculum. These approaches encourage students to explore real-world problems, collaborate with peers, and take intellectual risks, thereby fostering both curiosity and creativity. In addition, as articulated by Legi et al. (2023) and Pattiasina et al. (2024), children will be able to use their talents in real-life situations if there is a specific environment that encourages scientific attitudes using creativity. It is, however, useful to continue encouraging these methods because they are still effective in stimulating students' scientific creativity (Rampean et al., 2021; Tika & Agustiana, 2021). Therefore, it is now possible to incorporate contextualised science attitudes and motivational components into practical activities through project-based learning or inquiry-based learning.

CONCLUSION

This study reveals a significant and positive relationship between scientific attitudes and creativity among Indonesian secondary school students, with perseverance identified as the most impactful factor, explaining nearly 40% of the variance in creativity. This finding underscores the importance of fostering resilience and persistence in students, particularly in the context of science education, where complex problem-solving is essential. Open-mindedness and teamwork, as well as environmental sensitivity, are also important predictors of creativity, highlighting the role of social and collaborative skills in scientific innovation.

Gender differences were also observed, with female students scoring significantly higher on perseverance and environmental sensitivity. These differences, while moderate in effect size, suggest that gender may influence how students engage with scientific tasks. Interestingly, curiosity alone is insufficient for fostering creativity without a supportive learning environment. This underscores the need to integrate inquiry-based learning and project-based learning into the curriculum to provide students with opportunities for hands-on exploration and collaborative problem-solving. In terms of practical implications, his study suggests that educators should focus on developing students’ perseverance, collaboration skills, and environmental awareness to enhance their scientific creativity.

REFERENCES

Adi YW, Winarti ER & Adyanti R. (2023). Mathematical critical thinking skills ditinjau dari curiosity dengan pendekatan etnomatematika melalui kebudayaan Kabupaten Temanggung. *PRISMA, Prosiding Seminar Nasional Matematika 6*, pp. 614-619.

Ahmed, S. K. (2024). How to choose a sampling technique and determine sample size for research: A Simplified Guide for Researchers. *Oral Oncology Reports*, *12*, 100662.

Amaliyah NI, Aznam N & Dewi SS (2024). Analysis of students’ scientific attitude through experience practicum activities in chemistry learning. *Jurnal Penelitian Pendidikan IPA*, vol. 10, no. 1, pp. 19–27

Amruddin A, Priyanda R, Agustina TS, Ariantini NS, Rusmayani NGA L, Aslindar DA, ... Wicaksono D. (2022). *Metodologi penelitian kuantitatif*, Pradina Pustaka, Sukoharjo.

Apriansyah A, Haifaturrahmah Sari N, Nizaar M & Alaa S (2024). Project-based learning model on elementary school students’ science process skills and creative thinking skills. *Jurnal Ilmiah Sekolah Dasar*, vol. 8, no. 1, pp. 120–128.

Aswita, D. (2020). Experiential education for meaningful learning: A literature study', *Proceeding Book of the 3rd International Conference on Multidisciplinary Research*, vol. 3, no. 2, pp. 83–92.

Belova T, Islamov AE, Rozhnov AA, Zhdanov SP, Sokolova EI & Tsomartova DA (2024). Do gender and science success moderate the effects of science learning self-efficacy on science identity?' *Frontiers in Education*, vol. 9.

Fernandez SM, Madelo PK, Suico RAL, Cane JF, Magsayo J, Capuyan M, Siew NM & Acut D (2024). 'Thinking what no one else has thought: Investigating the scientific creativity of primary school students in a science class', *Center for Educational Policy Studies Journal*, pp. 1-30, https://doi.org/10.26529/cepsj.1514.

Hair, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., Danks, N. P., & Ray, S. (2021). *Partial least squares structural equation modelling (PLS-SEM) using R: A workbook*. Cham, Switzerland: Springer.

Halini, R, Z., Pasaribu, R. L., Mirza, A., & Afriansyah, E. A. (2023). Students' Scientific Attitudes and Creative Thinking Skills. Mosharafa: Jurnal Pendidikan Matematika, 12(2), 315–326. https://doi.org/10.31980/mosharafa.v12i2.786

Haryanto PC & Arty IS. (2019). The application of contextual teaching and learning in natural science to improve student's HOTS and self-efficacy. *Journal of Physics: Conference Series*, vol. 1233, no. 1, p. 012106.

Hornstra L, van Weerdenburg M, van den Brand M, Hoogeveen L & Bakx A. (2022). High-ability students' need satisfaction and motivation in pull-out and regular classes: A quantitative and qualitative comparison between settings. *Roeper Review*, vol. 44, no. 3, pp. 157–172, https://doi.org/10.1080/02783193.2022.2071367.

Hunaepi H, Suma IK & Subagia IW. (2024). Curiosity in science learning: A systematic literature review. *International Journal of Essential Competencies in Education*, vol. 3, no. 1, pp. 77–105, https://doi.org/10.36312/ijece.v3i1.1918.

Indrašienė V, Jegelevičienė V, Merfeldaitė O, Penkauskienė D, Pivorienė J, Railienė A, Sadauskas J & Valavičienė N. (2021). 'Linking critical thinking and knowledge management: A conceptual analysis'. *Sustainability*, vol. 13, no. 3, p. 1476.

Jung, I, & Lee, J (2022). Open thinking as a learning outcome of open education: Scale Development and validation. *Distance Education*, vol. 43, no. 1, 119–138.

Kaufman, J. (2012). Counting the muses: Development of the Kaufman Domains of Creativity Scale (K-DOCS). *Psychology of Aesthetics, Creativity, and the Arts*, vol. 6, no. 4, pp. 298–308.

Kemdikbudristek 2023, *PISA 2022 dan Pemulihan Pembelajaran di Indonesia*, available at: https://balaibahasariau.kemdikbud.go.id/wp-content/uploads/2023/12/LAPORAN-PISA-KEMENDIKBUDRISTEK.pdf

Kenett, Y., Humphries, S & Chatterjee, A. (2023). A Thirst for Knowledge: Grounding Curiosity, Creativity, and Aesthetics in Memory and Reward Neural Systems. *Creativity Research Journal*, vol. 35, no. 3, pp. 412–426.

Legi, H, Damanik, D & Giban, Y (2023). Transforming Education Through Technological Innovation In The Face Of The Era Of Society 5.0. *Educente: Jurnal Ilmiah Pendidikan*, vol. 2, no. 2, pp. 102–108.

Löffler, CS & Greitemeyer, T. (2021). Are Women the more empathetic gender? The effects of gender role expectations. *Current Psychology*, vol. 42, no. 1, pp. 220–231.

Mansour, N. (2024). Exploring the Impact of Social, Cultural, and Science Factors on Students' STEM Career Preferences. *Res Sci Educ*.

Moore, R., & Foy, RLH. (1997). The scientific attitude inventory: A revision (SAI II). *Journal of Research in Science Teaching*, 34(4), 327–336.

Munna, AS, & Kalam, MA (2021). Teaching and learning process to enhance teaching effectiveness: A literature review. *International Journal of Humanities and Innovation (IJHI),* 4(1), pp. 1-4.

OECD 2023, *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*, OECD Publishing, Paris, https://doi.org/10.1787/53f23881-en.

Pattiasina, PJ, Lamaloang, LK & Santoso, RY. (2024). The Role of Communication in Creating and Collaborative Learning Environments. *International Journal of Social and Education (INJOSEDU)*, vol. 1, no. 3, pp. 705–717.

Perdana, R, Rudibyani, RB, Budiyono, Sajidan & Sukarmin. (2020). The Effectiveness of Inquiry Social Complexity to Improving Critical and Creative Thinking Skills of Senior High School Students. *International Journal of Instruction*, vol. 13, no. 4, pp. 477–490, https://doi.org/10.29333/iji.2020.13430a.

Pertiwi, RP, Sinensis, AR, Dewi, SEK, Dewi, TR & Septikasari, R. (2023). Implementation of Scientific Literacy in The Independent Curriculum (Merdeka Curriculum) at Elementary School. *Jurnal Ilmiah PGMI*, vol. 9, no. 2, pp. 136–144.

Poláková, M, Suleimanová, JH, Madzík, P, Copuš, L, Molnárová, I & Polednová, J. (2023). Soft skills and their importance in the labour market under the conditions of Industry 5.0. *Heliyon*, vol. 9, no. 8, https://doi.org/10.1016/j.heliyon.2023.e18670.

Rampean, B, Roheti, E, Septriwanto, J & Lengkong, M. (2021). How Can Open Inquiry Enhancing Students' Scientific Attitude Through Chemistry Learning? *Advances in Social Science, Education and Humanities Research*.

Robitzsch, A. (2020). Why ordinal variables can (almost) always be treated as continuous variables: Clarifying assumptions of robust continuous and ordinal factor analysis estimation methods. *Frontiers in Education*, *5*.

Sepuru, M, Musonda, I, & Okoro, CS. (2020). An assessment of factors influencing collaboration impacts on Organisational Performance: A Review. *Advances in Science, Technology & and Innovation*, 321–325.

Stolaki, A, Satratzemi, M, & Xinogalos, S (2023). 'Examining the effects of creativity, collaboration, creative diversity and autonomy on Team Creative Performance', *Thinking Skills and Creativity*, *50*, 101415. https://doi.org/10.1016/j.tsc.2023.101415

Sukarni, W, Jannah, N, Qoriyana, D & Zain, MS. (2020). Scientific Attitude Identification and Interest of Pursuing Career in the Physics. *Tarbiyah: Jurnal Ilmiah Kependidikan*, vol. 9, no. 1, pp. 66–77.

Sun, M, Wang, M & Wegerif, R. (2020). Effects of divergent thinking training on students' scientific creativity: The impact of individual creative potential and domain knowledge. *Thinking Skills and Creativity*, vol. 37, p. 100682.

Tika, IN & Agustiana, IG. (2021). The Effect of a Blended Learning Project Based Learning Model on Scientific Attitudes and Science Learning Outcomes. *Jurnal Ilmiah Sekolah Dasar*, vol. 5, no. 4, pp. 557–566.

Wijaya, AAZ, Yusuf, M & Fitriani, A. (2022). Hubungan antara Grit dengan Regulasi Diri Dalam Belajar pada Siswa Kelas XII SMA Negeri. *Jurnal Ilmiah Psikologi Candrajiwa*, vol. 7, no. 1, pp. 47–59, https://dx.doi.org/10.20961/jip.v6i2.59824.

Wu, Y & Koutstaal, W. (2022). Creative flexibility and creative persistence: Evaluating the effects of instructed vs autonomous choices to shift vs. dwell on divergent and convergent thinking. *Consciousness and Cognition*, vol. 105, p. 103417.

Xu, S, Reiss, M. & Lodge, W. (2024). Enhancing scientific creativity through an inquiry-based teaching approach in secondary science classrooms. *International Journal of Science Education*, pp. 1–18, https://doi.org/10.1080/09500693.2024.2419987.

Zhang Y, Wang Y & Su Y. (2024). From no Distinction to Direction, The Impact of Motivation on Creativity: The Contribution of Environmental Resources and Grit. *Thinking Skills and Creativity*, 53, 101609. https://doi.org/10.1016/j.tsc.2024.101609