International Journal of Contextual Science Education (IJCSE)
e-ISSN: 3046-8876
Vol. 2, No. 2, June 2025
PP. 73-81.

Analysis of Junior High School Students' Scientific Creativity Profiles in Terms of Gender Differences and Cognitive Levels

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Accepted: June 2nd 2025, Approved: June 25th 2025, Published: July 7th 2025

Abstract— Creative thinking skills are among the essential competencies students must possess to face global challenges in the 21st century. This study aims to analyze the profile of students' scientific creativity in terms of gender differences and cognitive level. A descriptive quantitative method was employed, involving 36 junior high school students. The instruments used included a scientific creativity test based on the Hu & Adey model and documentation of students' science grades to determine their cognitive levels. Data analysis consisted of both descriptive and inferential approaches. Descriptive analysis was used to examine the characteristics of the data, including maximum score, minimum score, and average student score. Based on the scientific creativity scores, students were categorized into three groups: creative, moderately creative, and less creative. Inferential analysis involved an independent sample t-test to examine gender differences in scientific creativity and a Pearson correlation test to investigate the relationship between scientific creativity and cognitive level. The results showed that students' scientific creativity fell into the moderately creative category, with female students achieving higher average scores than male students, particularly in the dimensions of fluency and originality. The t-test revealed a significant difference in scientific creativity between male and female students. Students with higher cognitive levels tended to have better scientific creativity scores, although the Pearson correlation test showed that the relationship between cognitive level and scientific creativity was not statistically significant. In conclusion, female students demonstrated higher levels of scientific creativity than their male counterparts, and cognitive level did not show a significant correlation with students' scientific creativity.

Keywords— scientific creativity, cognitive level, gender differences, junior high school students
How to Cite— Nirmala, S. A., Rokhmat, J., Ramdani, A., & Sukarso, A. (2025). Analysis of Junior High School Students' Scientific Creativity Profiles in Terms of Gender Differences and Cognitive Levels. International Journal of Contextual Science Education, 2(2), 73–81. https://doi.org/10.29303/ijcse.v2i2.1025

1. Introduction

In the 21st century, creative thinking skills are essential competencies that students must possess to address global challenges and solve problems innovatively [1]. Amid the rapid technological advancements, fostering students' creative thinking skills has become increasingly crucial in preparing them to face the demands of work life. The 4C skills, creative thinking, critical thinking, communication, and collaboration, are key factors in students' development and success across various domains [2], [3]. An educational system that integrates creativity, critical thinking, and collaboration not only supports students' success in school but also nurtures individuals who can contribute meaningfully to the work life and society [4], [5]. Creative thinking skills should be possessed not only by students but also by teachers, as they enable more effective teaching and positively impact the learning process [6].

In science education, scientific creativity is a concrete manifestation of creative thinking skills. Scientific creativity extends beyond simply generating new ideas; it also encompasses the ability to formulate problems, construct hypotheses, conduct experiments, and draw logical and imaginative conclusions [7]. However, various studies have shown that students' scientific creativity, particularly among junior high school students, remains relatively low [2], [8]. Students often struggle to develop original ideas and to solve scientific problems creatively [9]. This is further supported by field observations, which reveal that most junior high school students have not yet demonstrated optimal scientific creative thinking skills, especially in the areas of fluency, flexibility, and originality.

One factor that can influence scientific creativity is gender. Gender affects how students process information, respond to challenges, and engage with learning activities [10]. Several studies have reported differences in scientific creativity between male and female students in various aspects, such as fluency of ideas, flexibility of thinking, and originality [11]. However, these findings remain contradictory and warrant further analysis to gain a more accurate understanding of students' scientific creativity profiles based on gender.

In addition to gender, students' cognitive levels are also believed to be closely linked to scientific creativity. Higher cognitive levels are often associated with better thinking skills, including scientific creativity [12]. However, some studies have shown that the relationship between cognitive levels and scientific creativity is not always significant [13]. This indicates that scientific creativity is not solely dependent on academic abilities but also influenced by factors such as the environment, learning experiences, and the teaching methods employed [11], [14].

Based on the above discussion, this study aims to analyze the profiles of junior high school students' scientific creativity in terms of gender differences and cognitive levels, to provide foundational knowledge for developing more inclusive and effective instructional models to enhance students' scientific creativity. The findings are expected to support teachers and educational practitioners in designing teaching approaches that can optimally foster students' scientific creativity regardless of gender and cognitive level differences.

2 METHODS

2.1 Research Design and Sampling

This research employed a descriptive quantitative design. The study was conducted at SMP Negeri 1 Narmada, one of the public junior high schools in the province of West Nusa Tenggara, Indonesia. The sampling technique used was purposive sampling. The research sample consisted of 36 students, including 22 male and 14 female students. The participants were eighth-grade students, approximately 13-14 years old.

2.2 Data and Data Collection Techniques

Data collection in this study employed a Scientific Creativity Test (SCT) was developed by Hu & Adey [7], which was adapted into Indonesian. The structural model of scientific creativity encompasses three main dimensions (fluency, flexibility, originality), processes (thinking, imagination), and products (scientific knowledge, technical products, scientific phenomena, scientific problems). Each subdimension was measured through specific test questions [7], [15]. The scientific creativity test consisted of seven open-ended questions designed to measure seven aspects of scientific creativity. Some modifications were made to contextualize the questions to the students' conditions. The aspects of scientific creativity, questions, and scoring guidelines are detailed in Table 1. In addition to data on scientific creativity, the study also utilized science subject report card scores to determine students' cognitive levels.

Table 1. The Aspect of Scientific Creativity, Questioning, and Scoring Guidelines

Item	Aspects	Questions	Scoring
1	Unsual Use	Glass is a material that we frequently encounter in our daily lives and offers numerous benefits. Please provide as many scientific uses or advantages of a piece of glass as possible (more than one answer is allowed).	**Question No 1 – 4** *The fluency* score is obtained by counting the total number of responses provided by the participant, regardless of their quality. *The flexibility* score is obtained by counting the number of different approaches or categories used in the responses. *The originality* score is based on how infrequently a given response occurs. If the probability of a particular response is less than 5%, it is assigned 2 points. If the probability of the response is between 5% and 10%, it is assigned 1 point. If it exceeds 10%, it is assigned 0 points. **Question No. 5** *The flexibility* score is obtained based on the number of ways proposed by the student to divide the square. Each method of division is assigned 1 point. *The originality* score is determined by recording all the answers provided by all participants and then evaluating each answer based on its rarity. If the probability of a response is less than 5%, it is assigned 3 points; if the probability is between 5% and 10%, it is assigned 2 points;
2	Finding the problem	If you were an astronaut and had the opportunity to travel into outer space aboard a spacecraft, and you arrived at a specific planet, what scientific questions would you like to investigate? Please write down as many questions as you can.	
3	Development Product	Bicycles are a mode of transportation that is widely utilized in daily life. Please consider as many ways as possible to improve or modify a standard bicycle to make it more appealing, more useful, and more aesthetically pleasing!	
4	Scientific imagination	Gravity is the force of attraction between two objects that possess mass. Humans can stand upright on Earth because of the gravitational force of the planet. Imagine if there were no gravitational force; what do you think the condition of our Earth would be like? (More than one answer is allowed.)	
5	Problem solving	Use as many methods as you can think of to divide a square into four equal parts that are also identical in shape. Draw the results on your answer sheet.	

Item	Aspects	Questions	Scoring
6	Scientific experiment	You are a student at SMPN 1 Narmada who lives in the city of Mataram. You observed that the river water in Mataram differs from the river water in Narmada. Noticing this difference, you are interested in testing the two types of water. In your opinion, how can you determine which water is better? Please write down as many methods as you can, including the equipment used, the scientific principles involved, and the basic procedures.	and if the probability exceeds 10%, it is assigned 1 point. **Question No. 6** *The fluency* score is calculated based on the number of correct methods proposed by the student, with each method assigned 1 point. *The flexibility* score is assessed based on the completeness of the tools, principles, and procedures; each aspect is assigned 3 points. *The originality* score is calculated in the same manner as the originality scoring in item number 5.
7	Product Design	Narmada is known as a region that produces fruits, one of which is mangosteen. Design a tool or machine for picking mangosteen fruit. Draw the design of the tool, provide a name for it, and explain the function of each part.	**Question No 7** *The fluency* score is obtained based on the number of parts in the fruit-picking machine. *The flexibility* score is determined by the functions of the fruit-picking machine, with each function receiving 3 points. *The originality* score ranges from 1 to 5 points based on the overall impression after evaluating all the other scripts.

The validity test of the instrument employed a construct validity test, referencing empirical validity. The empirical validity (item-wise) was calculated using the Pearson Product-Moment Correlation with a critical r-table value of 0.299 [16]. The testing process was carried out using the SPSS application. The results of the testing indicated that for each item, the calculated r-value (correlation index) exceeded 0.299. This demonstrates that every statement item is valid. The reliability test was conducted using the Cronbach's alpha formula with a criterion value of 0.7 [16]. The testing results showed that this instrument was reliable, as indicated by a Cronbach's alpha value of 0.82, which surpasses the criterion value of 0.7.

2.3 Data Analysis

The data will be analyzed using inferential statistical techniques. Initially, the normality of the data distribution will be tested. For this purpose, the Kolmogorov-Smirnov test was conducted. Since the results of the KS-test show a p-value greater than 0.05, it indicates that the data are normally distributed [15]. Next, to examine whether there is a difference in scientific creativity between male and female students, an independent t-test analysis will be employed. Furthermore, to examine the relationship between academic level and scientific creativity, Pearson's correlation test will be used.

To determine the level of students' scientific creativity, the scientific creativity scores will be categorized into three levels: high, moderate, and low. The interval for each group is determined using the following formula [15] :

$$interval\ coefficient = \frac{Maximum\ score - Minimum\ score}{3}$$

The highest score obtained in this study was 91, while the lowest score was 21, so the interval coefficient was 23. The group scores corresponding to this range are presented in Table 2.

Table 2. The level of scientific creativity

The category of creativity	Score interval
Creative	69 - 91
Moderately creative	45 - 68
Less creative	21 - 44

3. Results

3.1 Analysis Based on Gender

This section presents the results of students' scientific creativity scores in junior high school, categorized by gender differences. Details of the highest score, the lowest score, and the mean score for each aspect of scientific creativity are presented in Table 3.

Table 3. Statistical Description of Scientific Creativity Aspects Based on Gender

Item	Scientific Creativity Aspects	Male			Female		
		Max	Min	Mean	Max	Min	Mean
1	Unusual use	13	3	5	16	3	8
2	Finding the problem	13	0	8	29	4	14
3	Product development	23	2	7	15	0	8
4	Scientific imagination	14	2	6	9	3	6
5	Problem solving	10	2	6	28	2	7
6	Scientific experiment	17	0	3	14	3	7
7	Product design	21	0	12	16	11	11
	Total			46			59

Based on Table 3, in general, the average scores of the female student group were higher than those of the male student group. Looking at the mean scores, female students outperform in nearly all aspects of scientific creativity, except for scientific imagination and product design. In the aspect of scientific imagination, the average scores of male and female students were equal, whereas in the aspect of product design, male students had higher scores than female students. A comparison of scientific creativity scores between male and female students is presented in Figure 1.

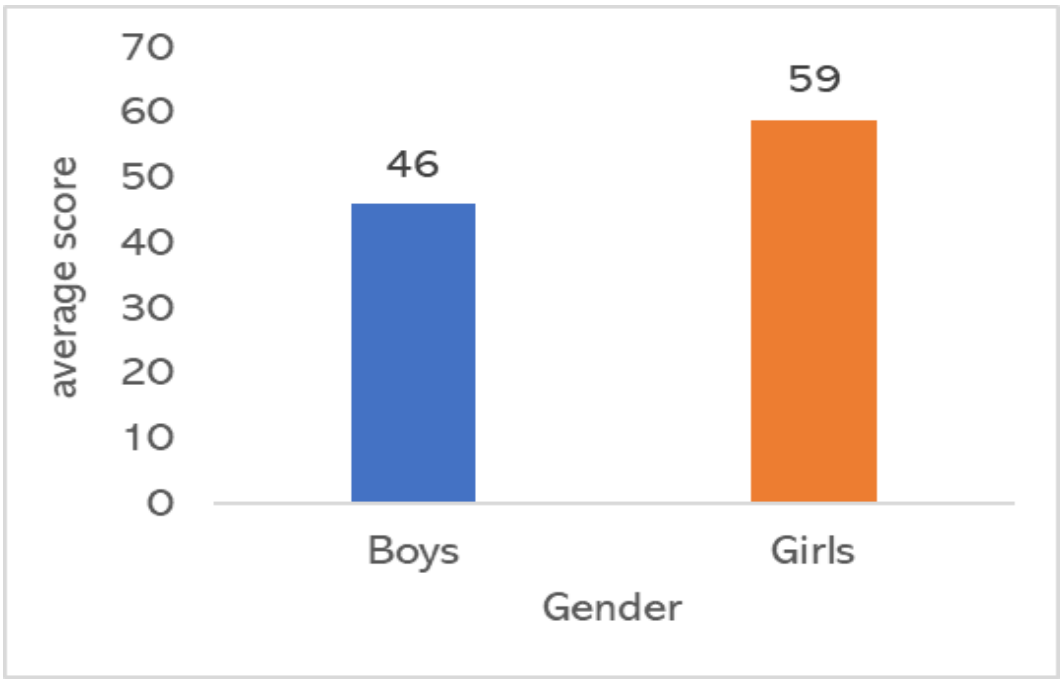

Fig. 1. Comparison of the Average Scores of Junior High School Students' Scientific Creativity Based on Gender

As a further analysis, to determine whether there was a significant difference between the male and female student groups, a statistical t-test was conducted. The results of the t-test for both groups are presented in Table 4.

Table 4. Results of the T-Test on Scientific Creativity in Male and Female Student Groups

	Gender	Mean	df	t Stat	P(T<=t) one-tail	t Critical one-tail	P(T<=t) two-tail	t Critical two-tail
Scientific Creativity	male	45,86364	34	2,79765	0,004207	1,690924	0,008415	2,032245
	female	59,28571						

As shown in Table 4, the two-tailed p-value of the t-test result was 0.008415, which was smaller than the significance level set by the researcher, which was 0.05. This indicates that there is a significant difference in scientific creativity between male and female students. The findings of this study show that female students, aged 13–14 years, exhibit higher scientific creativity than male students. To obtain more detailed information, a t-test analysis was also conducted for each aspect of scientific creativity individually. The results of this analysis are presented in Table 5.

Table 5. Results of the T-Test for Each Aspect of Scientific Creativity

Item	Scientific creativity aspects	Gender	Mean	df	t Stat	P(T<=t) one-tail	t Critical one-tail	P(T<=t) two-tail	t Critical two-tail
1	Unusual use	*male*	5,409	34	2,033	0,025	1,691	0,050	2,032
		female	7,786						
2	Finding the problem	*male*	7,5	34	3,387	0,001	1,691	0,002	2,032
		female	13,5						
3	Product development	*male*	6,818	34	0,484	0,316	1,691	0,631	2,032
		female	7,643						
4	Scientific imagination	*male*	5,591	34	0,021	0,492	1,691	0,983	2,032
		female	5,571						
5	Problem solving	*male*	5,545	34	0,918	0,183	1,691	0,365	2,032
		female	6,929						
6	Scientific experiment	*male*	3,455	34	2,581	0,007	1,691	0,014	2,032
		female	6,5						
7	Product design	*male*	11,55	34	0,131	0,448	1,691	0,897	2,032
		female	11,36						

Based on Table 5, there are three aspects of scientific creativity with p two-tailed values equal to or below the significance level of 0,05, they are the aspect of unusual uses (0.050), the aspect of problem finding (0,02), and the aspect of scientific experiment (0,014). This indicates that there are significant differences in these three aspects of scientific creativity. In contrast, the p-two tail values for the other four aspects—product development, scientific imagination, problem solving, and product design—indicate no significant differences between the two groups.

In addition to analyzing the seven aspects of scientific creativity, further analysis was conducted on the elements of scientific creativity, namely fluency, flexibility, and originality. The results of this analysis are presented in Table 6.

Table 6. Results of the T-Test Analysis on the Elements of Scientific Creativity

Elements	Gender	Mean	df	t Stat	P(T<=t) one-tail	t Critical one-tail	P(T<=t) two-tail	t Critical two-tail
Fluency	Male	12,27273	34	-2,34518	0,012496	1,690924	0,024993	2,032245
	Female	15,78571						
Flexibility	Male	16,63636	34	-1,85091	0,036443	1,690924	0,072887	2,032245
	Female	19,85714						
Originality	Male	16,95455	34	-2,82529	0,003925	1,690924	0,00785	2,032245
	Female	23,64286						

Based on Table 6, it can be seen that the p-two tail values for the aspects of fluency and originality are below the significance level of 0,05, namely 0,024993 and 0,00785, respectively. This indicates that there are significant differences between male and female students in the elements of fluency and originality. In contrast, for the element of flexibility, there is no significant difference between the two groups.

According to the interval scores established by the researcher, the level of scientific creativity of students is categorized into three groups: creative, moderately creative, and less creative. The percentages of students falling into each category are presented in Figure 2.

It can be seen that, for male students, the majority fall within the category of less creative, with only 9% of male students categorized as creative. In contrast, 64% of female students fall within the moderately creative category, with only 14% in the creative category. Overall, regardless of gender, the scientific creativity of junior high school students is considered low, with only a few students classified as creative. When viewed in terms of gender, female students exhibit better scientific creativity than male students

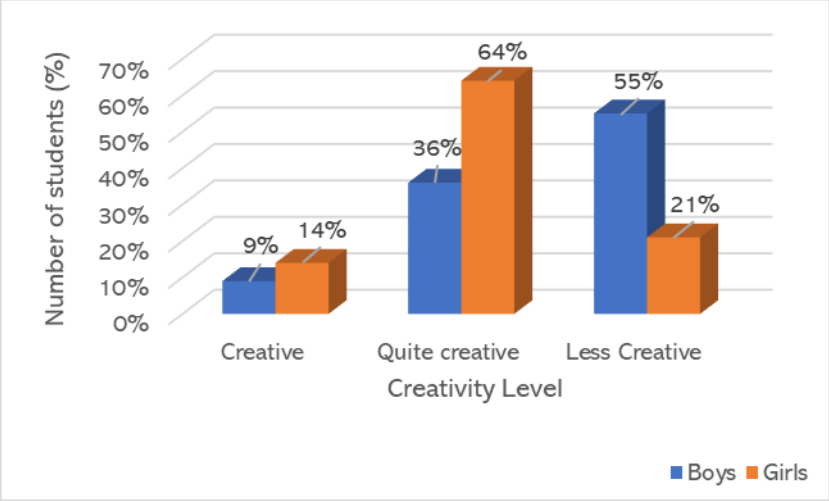

Figure 2. Comparison of the Percentage of Students in Each Scientific Creativity Level Group Based on Gender

3.2 Analysis Based on Cognitive Ability

This section presents the results of scientific creativity as reviewed from the students' cognitive level. The cognitive level of the students was determined by their report card grades in the science subject. Based on these grades, the students were categorized into three cognitive levels: high, moderate, and low. The percentage of students' scientific creativity levels, based on the number of students and their relationship with cognitive level, is presented in Table 7.

Table 7. Percentage of Students in Each Cognitive Level Group Based on Scientific Creativity

Scientific Creativity Level	Cognitive Level					
	High		Moderate		Low	
	N	%	N	%	N	%
Creative	2	25%	1	5%	1	17%
Moderately creative	5	63%	11	50%	1	17%
Less creative	1	13%	10	45%	4	67%
Total	8		22		6	

Based on Table 7, in the group of students with high cognitive ability, the highest percentage is 63%, falls within the moderately creative level. In the group of students with moderate cognitive ability, the highest percentage is 50%, is also in the moderately creative level. In the group of students with low cognitive ability, the highest percentage, 67%, falls within the less creative level. These findings indicate that students with low cognitive ability tend to be classified as less creative.

This result will be further analyzed using Pearson's correlation test. Pearson's correlation test was used to determine the relationship between scientific creativity and students' cognitive levels. The results of the Pearson's correlation test are shown in Table 8.

Table 8. Results of Pearson's Correlation Test for the Groups

		Cognitive	Creativity
Cognitive	Pearson Correlation	1	.246
	Sig. (2-tailed)		.148
Creativity	Pearson Correlation	.246	1
	Sig. (2-tailed)	.148	
	N	36	36

Based on Table 8, the correlation coefficient is 0,246. According to Sundayana (2020), this coefficient falls within the low category. Furthermore, the sig. (2-tailed) value is 0,148, which is greater than the critical threshold of 0.05, indicating that there is no significant relationship between these two variables (Sundayana, 2020). Next, an analysis of the elements of scientific creativity within each cognitive level group will be conducted. The statistical description of the elements of scientific creativity among students, based on their cognitive level, is presented in Table 9.

Table 9. Statistical Description of Scientific Creativity Elements Based on Students' Cognitive Level

Cognitive Level	Score of Scientific Creativity								
	Fluency			Flexibility			Originality		
	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
High	25	8	16,63	25	16	20,25	31	15	24,125
Moderate	19	6	12,95	32	11	17,68	32	11	18,136
Low	17	6	12,17	32	9	15,5	42	6	18,667

Based on Table 9, it can be seen that the mean score for scientific creativity in the group with a high cognitive level tends to be the highest among all groups, both in the elements of fluency, flexibility, and originality.

4. Discussion

Based on the results of this study, it was found that the scientific creativity of junior high school students generally falls into the moderate or moderately creative category. This study also revealed that there was a significant difference in scientific creativity between male and female students. The average scientific creativity score of female students is higher than male students, particularly in the dimensions of fluency and originality. This finding is in line with the research by Annisa et al., which found that gender affects the mathematical creative thinking abilities of junior high school students. Female students appeared to outperform in terms of flexibility, originality, and elaboration, while male students were superior only in the indicator of fluency. Therefore, overall, female students demonstrated higher mathematical creative thinking abilities compared to male students [17]. Research by Yao and colleagues also showed that female students possess higher levels of mindfulness, which helps them to be more creative in scientific research compared to male students. They suggested that this might be related to physiological differences that influence emotions and creative thinking processes [18]. A similar observation was reported by Fadiawati et al., who noted that in most aspects, female students' scientific creativity was slightly higher than that of male students, although statistical analysis revealed no significant differences in scientific creativity between the two groups [14]. The trend of higher scientific creativity scores among female students compared to male students was also reported by Jia and colleagues [19]. However, other studies have reported the opposite, suggesting that male students exhibit higher creative thinking abilities than female students [8]. The differences in creativity between males and females are more strongly influenced by social and environmental experiences rather than inherent differences [14], [20]. Many factors influence creativity, such as gender, ethnicity, socioeconomic status, and other demographic variables [11].

The second finding of this study concerns the relationship between the scientific creativity of junior high school students and their cognitive level. The data showed that students with high and moderate cognitive levels fall within the moderately creative category, whereas students with low cognitive levels are categorized as less creative. Furthermore, students in the high cognitive level group tend to have the highest mean scientific creativity scores among all groups. This finding is consistent with previous research suggesting that cognitive level is generally positively correlated with creative thinking skills [12]. However, the statistical analysis in this study did not show a significant relationship between scientific creativity and students' cognitive level. This means that although there is a tendency for higher cognitive levels to be associated with higher creativity, this relationship is not strong enough to be considered a direct influence.

The relationship between scientific creativity and cognitive ability is complex and influenced by many factors, such as environment and learning methods. Research by Shukri et al. demonstrated that creative thinking ability is positively correlated with science achievement, but cognitive ability alone is not sufficient to determine an individual's level of creativity. Creativity may emerge even without high academic achievement [21]. A meta-analytic study on creativity concluded that creativity contributes to academic achievement, but the influence varies depending on the aspect of creativity measured, such as idea fluency, flexibility, originality, and elaboration. This indicates that creativity cannot be assessed solely based on grades or academic performance [22]. This suggests that creativity has multiple dimensions and does not always align with conventional academic measures such as report card grades.

Meanwhile, Ayasrah et al. emphasized that the relationship between creativity and academic achievement is influenced by many factors both within and outside the student. In other words, academically high-achieving students do not necessarily have high creative thinking abilities [23]. The relationship between scientific creativity and academic or cognitive ability is indeed important, but it is not straightforward. It is influenced by various factors and dimensions. Creativity can certainly help students achieve academic success, but it does not stand alone. Creativity needs to be developed alongside cognitive abilities and other student characteristics. Therefore, a holistic educational approach is needed, one that encourages the simultaneous development of creativity and students' thinking skills.

5. Conclusion

The scientific creativity of junior high school students, particularly at SMP Negeri 1 Narmada, generally falls within the moderate or moderately creative category. The results of this study show that there is a significant difference between the scientific creativity of male and female students, with female students having a higher average scientific creativity score than male students, particularly in the dimensions of fluency and originality. In addition to examining scientific creativity and gender differences, this study also investigated scientific creativity and students' cognitive levels. Students with high and moderate cognitive levels were categorized as moderately creative, while those with low cognitive levels fall within the less creative category. Furthermore, the mean scientific creativity score of students in the high cognitive level group tended to be the highest among all groups.

The practical implication of this research suggests that teachers need to develop more flexible and responsive learning approaches that foster students' scientific creativity regardless of gender and cognitive levels. Curriculum developers should design adaptive instructional materials and methods that emphasize the integration of fluency, flexibility, and originality in thinking, as well as facilitate activities that cultivate scientific curiosity and innovation, thereby creating an inclusive learning environment that comprehensively promotes students' creativity.

6. Recommendation

Further research is needed to examine the relationship between students' scientific creativity and factors such as gender and cognitive level. In this study, the analysis was conducted descriptively using statistical data. To enrich understanding, in-depth studies on other factors that influence students' scientific creativity should be undertaken. Qualitative research with a deeper focus is particularly necessary to gain a comprehensive understanding of the relationship between scientific creativity, gender differences, and the cognitive level of students.

7. Acknowledgment

We extend our sincere gratitude to all parties involved in this research, especially to SMP Negeri 1 Narmada. This research received no external funding.

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