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Students' Self-Confidence and Mathematical Creativity through Visual Media-Assisted Problem-Based Learning: A Descriptive Study

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Abstract: Self-confidence and mathematical creativity are two essential competencies in 21st-century learning, yet they are often insufficiently addressed through conventional instructional models. This study aims to describe and analyze students' self-confidence and mathematical creativity after participating in a Problem-Based Learning approach supported by visual media. This study employed a quantitative approach using a quasi-experimental posttest-only control group design. The sample consisted of 50 fourth-grade students divided into an experimental and a control group. The research instruments included a self-confidence questionnaire and a mathematical creativity test, both of which had been validated and found reliable. Data were analyzed using an independent samples t-test after confirming the assumptions of normality and homogeneity. The results showed that the experimental group obtained significantly higher self-confidence scores (M = 67.68) than the control group (M = 61.28), with $p < .001$. Similarly, the mathematical creativity scores of the experimental group (M = 85.60) were higher than those of the control group (M = 75.80), with a p-value of .003. These results suggest a positive association between participation in visual media-based PBL and students' self-confidence and mathematical creativity. The findings indicate that the visual media-based PBL approach may support the development of both affective and cognitive competencies in elementary students. This study provides practical insights for educators in implementing contextual learning strategies that align with the demands of 21st-century education.

Keywords: problem-based learning, visual media, self-confidence, mathematical creativity.

▪ INTRODUCTION

In the era of globalization and the 4.0 industrial revolution, mathematics education is not only required to instill concepts and procedural skills, but also to develop higher-order thinking skills and student character (Maulidia, Johar, & Andariah, 2019). Two key aspects highlighted in 21st-century learning are creative thinking ability and academic self-confidence, as both are crucial in determining students' ability to tackle complex problems in the future (Foster, 2016). Creativity enables students to explore various approaches to problem-solving, while self-confidence gives them the courage to take intellectual risks and defend their opinions (Yazgan-Sag & Emre-Akdogan, 2016). Therefore, the development of these two aspects is an important part of creating independent, innovative, and solution-oriented learners (Hidayat, Susilaningsih, & Kurniawan, 2018).

Based on initial observations at one of the elementary schools where the research was conducted, it was found that lecture methods and routine problem-solving exercises still dominate mathematics learning. Students tend to be passive, reluctant to ask questions, and show limitations in expressing ideas when faced with non-routine problems. Additionally, the use of visual media in mathematics learning has not been optimally integrated into problem-based approaches. Visual media are often used as illustrations, rather than as tools to foster deep conceptual understanding (Henig, Ventura, & Ebbrecht-Hartmann, 2024). This situation indicates low stimulation of affective

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aspects, such as self-confidence, and cognitive aspects, such as creativity (Adharini & Herman, 2020).

Problem-Based Learning (PBL) has been recognized as one approach that can address these challenges (Affandy, Sunarno, Suryana, & Harjana, 2024). PBL places students in contextual problem-based learning situations, encouraging them to think critically, collaborate, and learn independently (Dorimana, Uworwabayeho, & Nizeyimana, 2022). This model provides students with space to develop original ideas and express their thoughts confidently (Xia et al., 2024). This approach is also aligned with Vygotsky's social constructivism theory, which emphasizes that effective learning occurs through social interaction, collaboration with peers, and support from teachers as scaffolding that helps students build understanding gradually (Bakker, Smit, & Wegerif, 2015). More than just a teaching strategy, PBL is an approach that builds lifelong learning skills, highly relevant to national education goals and the Pancasila learner profile (Suhendri & Suparman, 2019).

In the implementation of PBL, learning media support is very important. One potential medium is contextual images or image-based media (Ndiung & Menggo, 2024). This medium not only serves as a visual aid to clarify issues but also stimulates students' interest, empathy, and emotional engagement, contributing to increased self-confidence (Suherman & Vidákovich, 2022). Cognitively, images can form stronger connections, both concrete and abstract, thereby facilitating a deeper understanding (Bang, Li, & Flynn, 2023). According to self-efficacy theory (Bandura, 1997), positive and successful learning experiences strengthen an individual's belief in their own abilities. In this context, images used effectively in problem-based learning can provide meaningful learning experiences, thereby strengthening students' self-confidence in understanding and solving mathematical problems. Thus, the integration of images in PBL is believed to strengthen the simultaneous development of affective and cognitive aspects.

Recent studies on PBL and visual media have primarily been conducted separately. Studies examining the effects of PBL generally focus on improving critical thinking skills or overall learning outcomes, without considering affective aspects such as self-confidence (Hendriana, Johanto, & Sumarmo, 2018). Conversely, research highlighting the use of visual media has emphasized its effectiveness in aiding conceptual understanding, rather than its impact on students' character or creativity (bt Abdul Hamid & Kamarudin, 2021). This indicates that the combination of visual media-based PBL as a strategy to develop students' self-confidence and mathematical creativity remains a research gap worthy of further investigation (Yaniawati, Kariadinata, Sari, Pramiarsih, & Mariani, 2020).

Several previous studies reinforced the urgency of this research. Research by Desti, Pertiwi, Sumarmo, & Hidayat (2020) showed that the application of PBL can improve mathematical problem-solving skills; however, it has not addressed affective aspects, such as self-confidence. Research by Wu, Jiang, Long, & Zhang (2024) demonstrated that visual media are effective in clarifying mathematical concepts, but are not associated with the implementation of PBL. Meanwhile, research by Popova, Abdualiyeva, Torebek, Yelshibekov, & Omashova (2022) showed that student creativity can be enhanced through open-ended challenges, but does not involve visual elements or direct integration between PBL and visual media in developing both aspects simultaneously.

Based on this gap, this study is considered novel because it explores the potential of visual media-based PBL in supporting two aspects of student development: affective (self-confidence) and cognitive (mathematical creativity). This approach combines the strengths of the PBL model in fostering independent learning with the supportive role of visual media in stimulating engagement and conceptual understanding (Ahdhianto, Marsigit, Haryanto, & Nurfauzi, 2020). By integrating both, this study not only offers theoretical contributions to the development of integrated learning models but also provides practical solutions to the challenges of mathematics learning in elementary schools (Supandi, Suyitno, Sukestiyarno, & Dwijanto, 2021).

This study aims to describe and analyze the self-confidence and mathematical creativity of elementary school students who participated in visual media-based Problem-Based Learning. This study employed a quantitative approach, utilizing standardized instruments to measure both variables objectively. The research results are expected to contribute to enriching more participatory, contextual, and meaningful mathematics learning strategies. Thus, this study is part of efforts to improve the overall and sustainable quality of basic education.

▪ METHOD

Participants

This study was conducted at SD Negeri Kotagede Yogyakarta in the even semester of the 2024/2025 academic year. This school was selected purposively because it has two parallel classes in grade IV and students with diverse socio-cultural characteristics, making it suitable for the implementation of Problem-Based Learning (PBL). This situation also reflects the general characteristics of many elementary schools in Indonesia, so the research findings have the potential to be generalized (Kholid, Mahmudah, Ishartono, Putra, & Forthmann, 2024). Grade 4-A was designated as the experimental group receiving visual media-assisted PBL, while Grade 4-B served as the control group receiving conventional learning. Each class consisted of 25 students.

Research Design and Procedures

This study used a quantitative method using a quasi-experimental design, namely a posttest-only control group design. This design was chosen to minimize the influence of the pretest on student learning outcomes, allowing for direct observation of differences between groups through the posttest. Learning in the experimental group is based on the main principles of PBL, including the presentation of contextual problems, student-centered investigation, and reflection on learning outcomes (Pratiwi, Nugroho, Setyawati, & Raharjo, 2023). In its implementation, teachers utilized visual media to stimulate students' understanding of concepts and enhance their engagement with problems. In contrast, the control group received instruction through lectures and practice questions, without using visual media or a problem-solving approach. Despite only one session was conducted, the material was designed intensively and employed a contextual approach intended to stimulate students' affective and cognitive responses. The duration of the treatment, which was only one session for each group, is a limitation of this study that may affect the consistency of the learning effects.

Instruments

The research instruments consisted of two types, namely a self-confidence questionnaire (non-test) and a mathematical creativity test (test). The questionnaire was compiled using a five-point Likert scale (always, often, sometimes, rarely, never) and consisted of 20 statements. The mathematical creativity test consisted of essay questions designed to evaluate aspects of students' creative thinking in mathematical problem-solving contests. The indicators for each instrument are summarized in Table 1.

Table 1. Indicators in the mathematical self-confidence and creativity instrument

Instrument	Indicators'
Self-Confidences	1. Belief in one's own abilities. 2. Independence in decision-making 3. Positive self-concept. 4. Courage to express opinions.
Mathematical Creativity	1. Fluency 2. Flexibility 3. Originality 4. elaboration

Both instruments were validated by an expert lecturer in the field of mathematics education. The validation process involved evaluating the clarity of the wording, the relevance of the content, and the suitability of the indicators in relation to the construct being measured. The items in the instrument were revised based on this input until they were deemed suitable for use in the study. Furthermore, reliability testing was conducted using Cronbach's Alpha formula, with results of $\alpha = 0.82$ for the self-confidence questionnaire and $\alpha = 0.79$ for the mathematical creativity test, indicating that both instruments have high reliability and are suitable for use in this study.

Data Analysis

Data collection was conducted through a posttest after treatments. The posttest was administered at the end of the learning session and given to both groups using the same instrument. The posttest data were analyzed using inferential statistics with the help of SPSS. Before conducting the difference test, the normality of the data was assessed using the Shapiro-Wilk test, while the Levene test was used to examine homogeneity. After all assumptions were met, an independent samples t-test was used to compare the posttest results between the experimental and control groups in terms of self-confidence and mathematical creativity, using a significance level of 5% ($p < 0.05$).

▪ RESULT AND DISSCUSSION

Learning in the experimental group was conducted by applying the visual media-based Problem-Based Learning (PBL) model in one session on the material of converting units of length, weight, and volume. One session was selected to observe how students responded cognitively and affectively to the contextual learning material within a limited implementation scope. The learning process began by presenting a contextual problem related to daily life, designed to encourage students to think creatively and develop problem-solving strategies (Lesmini & Hidayat, 2019). The teacher acts as a facilitator,

guiding students' thinking processes through prompting questions without directly providing solutions (Kardoyo, Nurkhin, Muhsin, & Pramusinto, 2020).

The learning media used are visual images displayed through PowerPoint slides, featuring illustrations of measuring instruments such as cm, m, kg, liters, and milliliters. This media is displayed as an initial stimulus to help students understand the context of the problems they will solve (Martínez-Gómez & Nicolalde, 2025). After the media is explained, students are asked to work in small groups to discuss solutions to the problem presented. The visual images serve as the primary reference for understanding the problem situation and stimulate active student engagement during the learning process (Asare & Adu Obeng, 2025).

Normality tests were conducted to ensure that the data analyzed had a distribution close to normal. This is a key requirement for the use of parametric analysis techniques, such as the independent samples t-test, which necessitates that the data in each group (experimental and control) have a normal distribution. Since the number of subjects in each group was less than 50 students, the Shapiro-Wilk test was used, which is statistically more accurate in detecting deviations from normality in small sample sizes than the Kolmogorov-Smirnov test. The results of the Shapiro-Wilk test for both variables, self-confidence and mathematical creativity, are presented in Table 2.

Table 2. Normality test of students' self-confidence and mathematical creativity scores

Self-Confidence Questionnaire Score	**Group**	**Statistic**	**Sig. (p)**
	Experiment	.120	.687
	Control	.108	.385
Mathematics Creativity Score	**Group**	**Statistic**	**Sig. (p)**
	Experiment	.143	.271
	Control	.134	.576

For the self-confidence variable, the Shapiro-Wilk significance value in the experimental group was 0.687, while in the control group it was 0.385. Both values are greater than the significance level ($\alpha = 0.05$), indicating that there is insufficient evidence to reject the null hypothesis (H_0), which states that the data come from a normally distributed population. Therefore, the assumption of normality is met for both the experimental and control groups.

For the mathematical creativity variable, the significance value in the experiment al group was 0.271, and in the control group was 0.576. Since both values exceed the threshold of 0.05, the data in both groups can be considered normally distributed. In addition to the statistical normality test, visual inspections were conducted using Q-Q plots to verify the normality of the data. The visualization results indicate that the data points in each group consistently follow a diagonal pattern, suggesting that the data distribution is approximately normal. No extreme patterns, such as outliers or noticeable skewness, indicating that the data does not exhibit significant distribution deviations.

As shown in Figure 1, both groups' data points align closely with the diagonal line, visually supporting the result that the data distribution is approximately normal. The absence of significant deviation from the line suggests that there are no skewness or outliers in the self-confidence scores. The same procedure was applied to the mathematical al creativity variable, as shown in Figure 2.

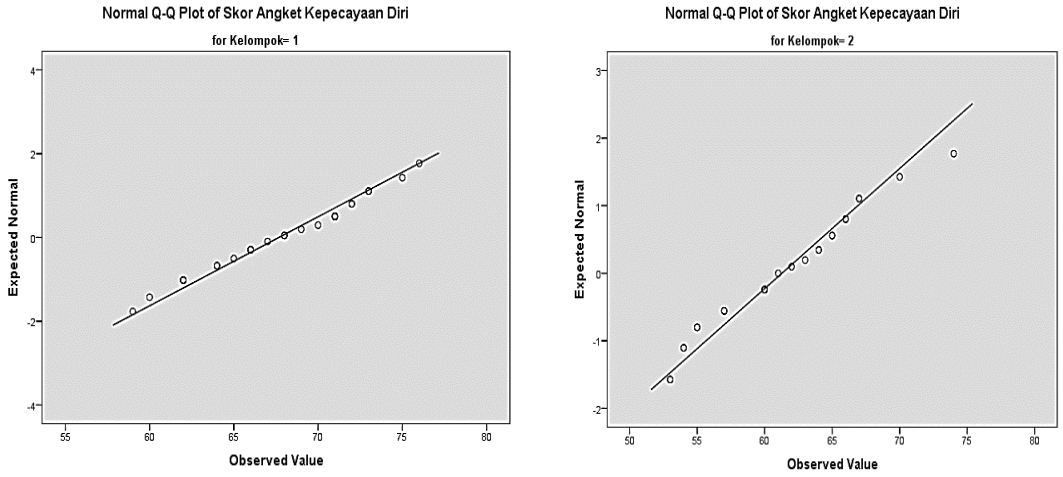

Figure 1. Q-Q plots of mathematical creativity scores in the experimental and control groups

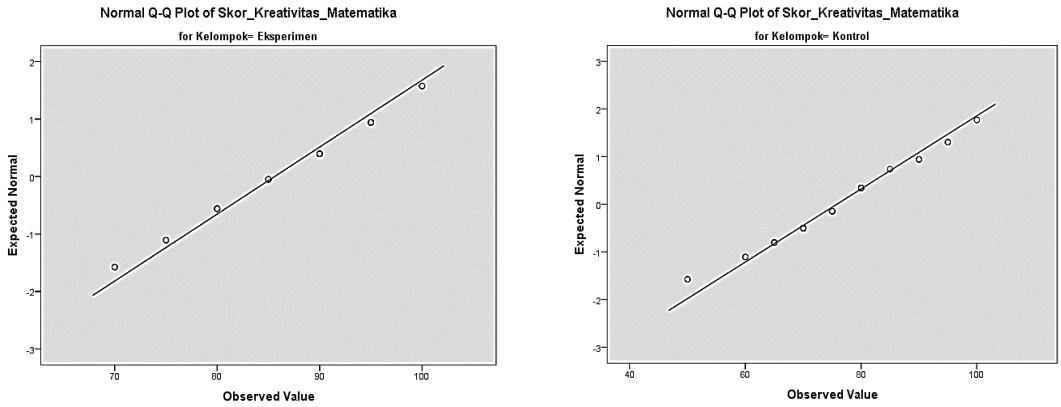

Figure 2. Q-Q plots of mathematical creativity scores in the experimental and control groups

As shown in Figure 2, the data points for both the experimental and control groups also closely follow the diagonal line. This further supports the notion that the creativity scores are normally distributed, with no noticeable skewness or outliers. Therefore, the assumption of normality is visually fulfilled for both measured variables.

In line with these visual results, the outcomes of the Shapiro-Wilk test also confirmed that the students' self-confidence and mathematical creativity scores in each group are normally distributed. Hence, the assumption of normality is fulfilled, making parametric statistical analysis techniques such as the independent samples t-test appropriate for testing the hypothesis of differences between the experimental and control groups. After the normality assumption was met, an independent samples t-test was conducted to test the self-confidence and mathematical creativity scores between the experimental and control groups.

Self-Confidence

To provide a more detailed description of students' self-confidence development, the mean scores for each indicator were compared between the experimental and control

groups. Figure 3 presents a bar chart illustrating the differences in mean self-confidence scores across the four indicators.

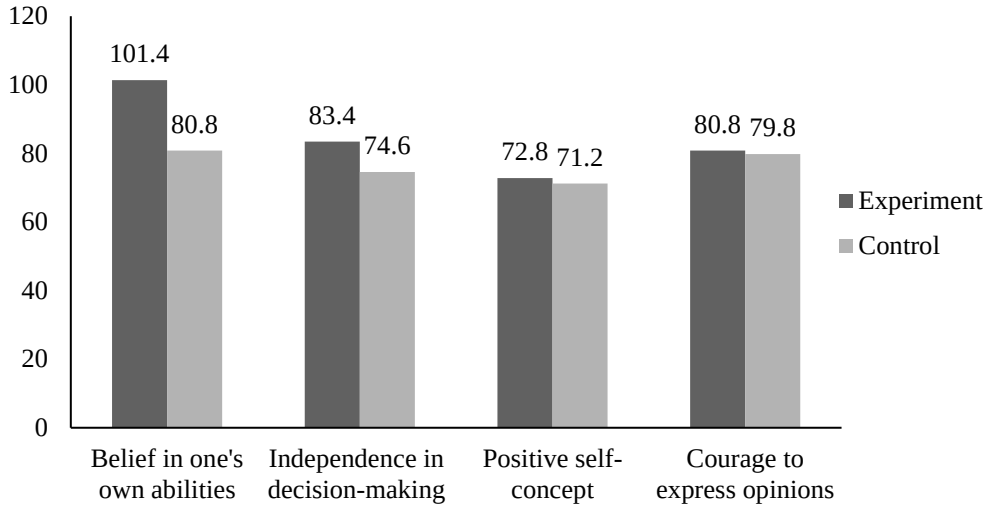

Figure 3. Comparison of mean self-confidence scores by indicator between experimental and control groups

As shown in Figure 3, the experimental group consistently achieved higher mean scores across all self-confidence indicators compared to the control group. The most notable difference was observed in the "Belief in one's own abilities" indicator, with a mean score of 101.4 in the experimental group compared to 80.8 in the control group. Other indicators, such as "Independence in decision-making," "Positive self-concept," and "Courage to express opinions," also showed higher means for the experimental group. These results suggest that the visual media-based Problem-Based Learning approach supports the development of self-confidence in a more comprehensive manner, influencing multiple dimensions rather than just overall scores.

Furthermore, these descriptive differences are consistent with the results of the independent samples t-test, which showed a statistically significant overall difference in self-confidence scores between the experimental and control groups ($p < .001$), as shown in the figure below. This confirms that the visual media-based PBL approach was effective in enhancing students' self-confidence in both overall score and specific dimensions.

These results indicate that the experimental group had an average self-confidence score of 67.68 (SD = 4.706), which was higher than that of the control group, with an average of 61.28 (SD = 5.624). A significance level of 0.000 or ($p < 0.001$) indicates that this difference is statistically significant. This means that the likelihood of this difference occurring by chance is very small, less than 0.1%. Thus, students who participated in visual media-based PBL demonstrated higher self-confidence scores, suggesting that this learning approach may support the development of self-confidence.

These findings may be related to the characteristics of the PBL model, which allows students to actively engage in collaborative and independent problem-solving processes (Sugiarti & Dewanti, 2018). Through challenging yet supportive learning situations, students are encouraged to express their opinions, work in groups, and make decisions.

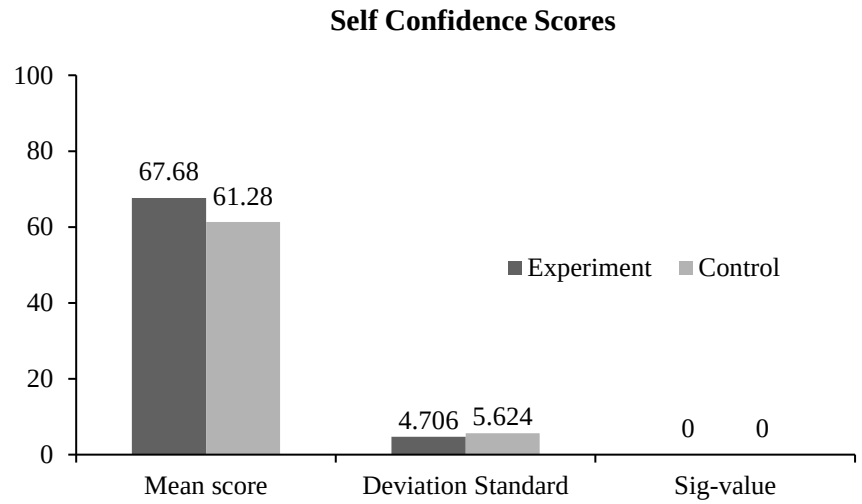

Figure 4. Bar chart showing mean, standard deviation, and significance of self-confidence scores in the experimental and control classes

This process may help support the development of students' self-confidence in facing academic challenges, which aligns with the findings of Ahmad, Akhsani, & Mohamed (2023), who observed that PBL may enhance students' self-confidence through active engagement, as it provides space for learners to participate actively and think independently. From Vygotsky's social constructivist perspective, this process reflects the practice of scaffolding, which is the support provided by teachers and peers to help students go beyond their zone of proximal development. Through social interaction in groups and guidance from teachers as facilitators, students develop the confidence to express their opinions, reflect on strategies, and gradually build their understanding. Furthermore, these results are reinforced by Apriliyani (2023) findings, which identify self-confidence as a key factor in driving student motivation and ability to manage independent learning strategies, especially when given responsibility for completing problem-based tasks. In this context, the use of visual media also strengthens self-confidence by clarifying information and reducing student confusion when understanding the context of the problem.

Theoretically, these results are consistent with Bandura's theory of self-efficacy, which posits that an individual's belief in their abilities determines the effort they put into facing challenges. Bandura explains that previous experiences of success (mastery experiences) are the main source of self-efficacy reinforcement (Bandura, 1997). In the context of this study, students' experiences in solving problems through PBL and visual media support a form of mastery experience that strengthened their self-confidence.

This is also supported by Gojkov-Rajić, Šafranj, & Gak, (2023) who explain that self-confidence plays a key role in triggering students' metacognitive processes, including in the context of decision-making and reflection on their problem-solving strategies.

Mathematical Creativity

To provide a more detailed description of students' mathematical creativity, the mean scores for each indicator were compared between the experimental and control groups. Figure 5 illustrates these differences across the four indicators in a bar chart.

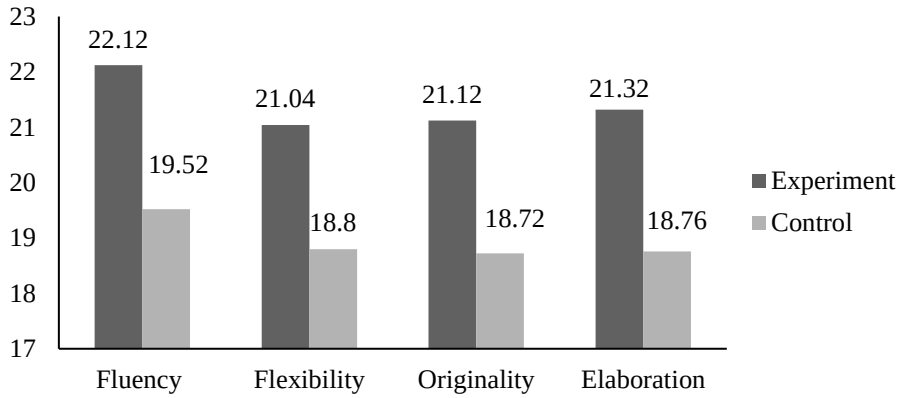

Figure 5. Comparison of mean mathematical creativity scores by indicator between experimental and control groups

As shown in Figure 5, the experimental group consistently achieved higher mean scores across all mathematical creativity indicators compared to the control group. Notable differences were observed in all four indicators (Fluency, Flexibility, Originality, and Elaboration), demonstrating that the visual media-based PBL approach supported a broad development of students' creative thinking in mathematics. Furthermore, these descriptive differences are consistent with the results of the independent samples t-test, which indicated a statistically significant overall difference in mathematical creativity scores between the experimental and control groups ($p = 0.003$), as presented in the figure/table below. This confirms that the visual media-based PBL approach was effective in enhancing students' mathematical creativity both overall and across its specific dimensions.

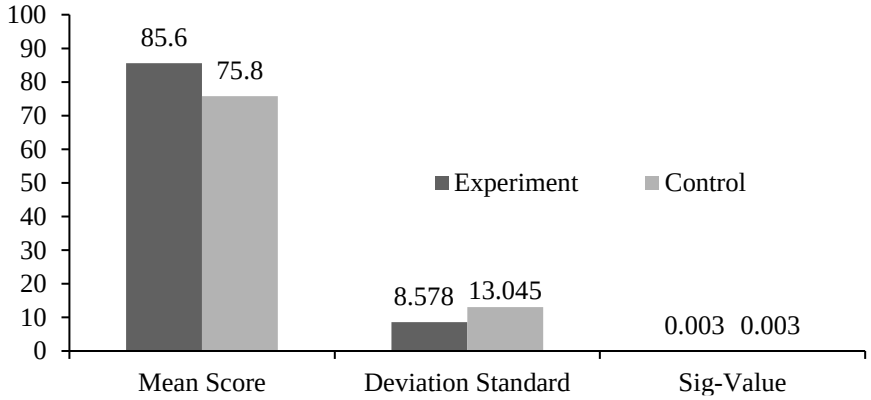

Figure 6. Bar chart showing mean, standard deviation, and significance of mathematical creativity scores in the experimental and control classes

The experimental group also showed higher mathematical creativity scores, with an average of 85.60 (SD = 8.578), compared to the control group, which had an average of 75.80 (SD = 13.045). A significance level of $p = 0.003$ indicates that the difference between the two groups is statistically significant. This suggests that students who

participated in visual media-based PBL tend to perform better in both affective and cognitive aspects.

The visual media-based PBL model was associated with higher mathematical creativity scores in the experimental group. This is evident from the higher average scores of the experimental group compared to the control group. These findings are consistent with the study by Bron & Prudente (2024), which shows that students who learn through a problem-based learning approach with visual support tend to demonstrate stronger creative thinking skills, particularly in terms of flexibility and elaboration of solutions. Visual media in learning play a crucial role as a concrete tool that bridges abstract concepts with real-world situations, enabling students to formulate solutions in a more original manner. Yayuk, Purwanto, As'ari, & Subanji (2020) emphasize that visualization in PBL activities helps students develop divergent thinking skills as they are required to creatively connect various elements of the images with different conceptual understandings.

Furthermore, this approach is also in line with the findings of Weng, Liu & Zhang (2023) who found that students' creativity develops optimally when they are exposed to contextual learning experiences that emphasize meaning construction. Visual media in this context serve as an effective means of stimulating creative thinking through observation, association, and deep reasoning.

Thus, the integration of PBL and visual media in mathematic learning may support conceptual understanding and provide an environment that encourages the development of creativity. This strategy may be considered by teachers as a potential way to foster critical and innovative thinking habits, which are crucial in addressing the challenges of 21st-century learning. However, to assess the long-term impact on self-confidence and creativity, further research with a long-term design is required.

▪ CONCLUSION

The visual media-based PBL model shows potential to support the development of students' confidence and creativity in mathematics learning. This approach provides a challenging yet supportive learning experience through visually presented contextual problem-solving. This allows students to be more confident in expressing their ideas and to think flexibly and originally when faced with mathematical problems. Practically, the results of this study suggest that teachers can utilize visual media more effectively in problem-based learning to reinforce students' understanding of abstract concepts while actively engaging them. This strategy aligns with the demands of contemporary learning, which requires critical and collaborative thinking activities in the classroom. To expand the scope of application, further research is recommended to examine this model in the context of other subjects, different educational levels, and longer intervention durations, in order to evaluate its sustainable impact and generalize its results more comprehensively. Based on these findings, the visual media-based PBL model may serve as an alternative learning strategy worth further exploration, supporting the development of 21st-century competencies in elementary schools.

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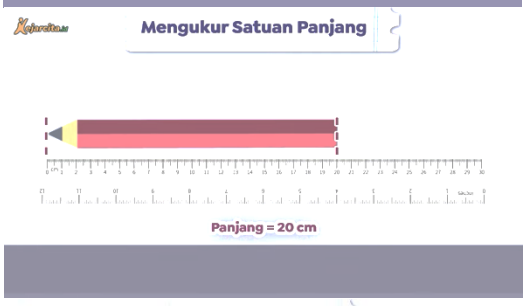
- **SUPPORTING INFORMATION**



Satuan Waktu

Satuan Waktu	Keterangan	Satuan Waktu	Keterangan
1 menit	60 detik	1 tahun	12 bulan
1 jam	60 menit	1 tahun	52 minggu
1 hari	24 jam	1 tahun	365 hari
1 minggu	7 hari	1 lustrum	5 tahun
1 bulan	4 minggu	1 windu	8 tahun
1 bulan	30 hari	1 dasawarsa	10 tahun
1 cawu	4 bulan	1 abad	100 tahun
1 semester	6 bulan	1 milenium	1.000 tahun