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Enhancing Elaboration Skills through Integrated STEM-PjBL: A Study on Object Movement and Living Creatures

Siti Rizqiyah Putri Dwi Ani[1] ✉, Parmin[2], Nugrahaningsih WH [3]

[1]Master of Science Education Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Semarang, Indonesia
[2]Science Education Study Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Semarang, Indonesia
[3]Biology Education Study Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Semarang, Indonesia

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Abstract

The Merdeka Curriculum aims to foster creative thinking and digital skills. Initial observations revealed a lack of critical thinking, particularly in students' elaboration skills, due to insufficient motivation, which led to passive learning behaviours. Integrated STEM Project-Based Learning (PjBL) is an educational approach designed to address 21st-century challenges by emphasizing project-based learning and providing students with scientific experiences applicable to problem-solving. This study aims to (1) analyze the impact of integrated STEM-PjBL on elaboration skills in the context of object movement and living creatures; (2) assess the extent of this impact; and (3) evaluate the overall effectiveness of integrated STEM PjBL on the topic. The research was conducted at SMP N 1 Sluke and SMP 1 Pancur using a quasi-experimental method with a Control-Group Interrupted Time-Series Design. The study employed pretest and post-test scores as test instruments and questionnaires and observations as non-test instruments. Data analysis was performed using SPSS. The observation results indicated that the experimental class scores were higher than those in the control class. The t-test values at SMP N 1 Pancur and SMP N 1 Sluke were below 0.05, demonstrating statistical significance. Pearson correlation analysis revealed r-values of 0.69 at SMP N 1 Sluke and 0.60 at SMP N 1 Pancur. The determination coefficient analysis showed that integrated STEM PjBL had a 64% impact on elaboration skills at SMP N 1 Sluke and a 72.72% impact at SMP N 1 Pancur. These values indicate that integrated STEM PjBL significantly influences their elaboration skills.

✉ correspondence:
Gedung D5 Lantai 1 FMIPA Universitas Negeri Semarang
rizqiyahkiki97@students.unnes.ac.id

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INTRODUCTION

Government Regulation of the Republic of Indonesia Number 57 of 2021 on National Education Standards stipulates that education should be a consciously planned effort to foster a learning process that develops students' potential. This includes their spiritual abilities, self-control, personality, intelligence, noble character, and skills necessary for themselves, society, the nation, and the state. The ultimate objective of Merdeka Curriculum is to enable students to think creatively and acquire digital skills (Baharrudin, 2021). The demands of 21st-century learning require individuals not only to master cognitive abilities but also to gain scientific experiences that can be applied to solve real-life problems (Haryanti & Sumarwa, 2018).

In implementing the Merdeka curriculum, educators have three options: independent learning, independent change, and independent sharing (Rahimah, 2022). Elaboration skills involve applying creativity and conceptual understanding. This research compared two learning models: a general discovery approach, which served as the control class, and integrated STEM Project-Based Learning (PjBL), which served as the experimental class. Both models were applied to the materials of object movement and living creatures. The comparison of these learning models can reveal a meaningful learning process and offer an alternative approach to enhancing students' creativity (Furi et al., 2018).

Technology is introduced through learning media that support the educational process, with these media playing a crucial role in making abstract concepts more tangible (Habib et al., 2020). Post-pandemic students' elaboration skills are notably limited, as observed by Himmah et al. (2021), who found that students generally underdeveloped their thoughts or ideas. Moreover, observations conducted on August 11, 2022, at SMP Negeri Sluke, Kabupaten Rembang, revealed that only 10% of the students could answer questions about the materials presented by the teacher. Additionally, interviews with teachers and students indicated that students struggled to apply or provide examples of scientific concepts in everyday life, highlighting a significant deficiency in elaboration skills at SMP N 1 Sluke, Kabupaten Rembang.

The importance of elaboration skills lies in students' ability to apply learned materials to their daily lives. A lack of elaboration skills is often influenced by students' disinterest in learning activities, leading to passive behaviour. Enhancing learning motivation can improve creative thinking skills (Suprapti, 2022). The choice of learning models significantly impacts the effectiveness and enjoyment of the learning process. Fatma (2021) noted that monotonous teaching methods contribute to a lack of student creativity. The observation conducted on February 2, 2023, at SMP N 1 Pancur, Kabupaten Rembang, revealed that only 3 out of 31 students were actively engaged in the learning process. Interviews with teachers at SMP N 1 Pancur also indicated that some teachers have not regularly implemented updated learning models that could encourage more active participation in learning activities.

PjBL is an educational approach that engages students in learning activities and provides additional time for them to solve problems individually or in groups (Natty et al., 2019). Research by Wasimin (2022) elucidated that project-based learning can enhance students' understanding of the material and foster the development of skills and character. Science, Technology, Engineering, and Mathematics (STEM) represent a collaborative approach that integrates these four disciplines to address real-life problems. PjBL and STEM complement each other, leveraging their strengths and addressing their weaknesses. This synergy helps students grasp the concept of product creation through the PjBL model and the engineering design process, resulting in products that are aligned with advancements in science and technology (Lutfi et al., 2018). According to Fatma (2021), STEM is crucial in the 21st century as it promotes various skills, including communication, critical thinking, leadership, teamwork, creativity, and resilience.

Based on the above description, in an effort to enhance creativity and conceptual understanding among students in the application of everyday concepts, it is necessary to research the influence of the integrated STEM-PjBL model on

elaboration skills, particularly in relation to the topic of object movement and living creatures.

METHODS

The research method used in this study was quasi-experimental, allowing the control of external variables that affected the course of the experiment. This study employed a Control-Group Interrupted Time-Series Design, which involved observing two groups over time, with only one group receiving the treatment. The research was conducted at SMP 1 Sluke and SMP N 1 Pancur in Rembang Regency.

The research was implemented in seventh-grade classes during the odd semester of the 2023/2024 academic year. The study population consisted of 31 students in the experimental class at SMP N 1 Pancur, 31 students in the control class at SMP N 1 Pancur, 29 students in the experimental class at SMP N 1 Sluke, and 29 students in the control class at SMP N 1 Sluke. The research involved one experimental class and one control class at each school. The experimental class adopted the integrated STEM-PjBL, while the control class applied the traditional PjBL. Data collected for this study included pretest and post-test scores, observation data, and questionnaire responses to assess the impact and implementation of integrated STEM-PjBL on the materials of motion and living creatures in relation to elaboration skills. Pretests and post-tests were administered at the first and last meetings. Data analysis involved T-test, Pearson correlation, and determination coefficient tests.

RESULTS AND DISCUSSION

The Influence of Integrated STEM-PjBL on the Materials of Object Movement and Living Creatures

Table 4.1 details the achievement of integrated STEM-PjBL on the materials of object movement and living creatures in relation to students' elaboration skills based on the observation results at each meeting per indicator.

Table 4.1 The Achievement of Integrated STEM Pjbl on the Materials of Object Movement and Living Creatures in Relation to Elaboration Skills

	N	The observed indicators	Achievement of Elaboration Skills. (%)							
			Meeting 1		Meeting 2		Meeting 3		Meeting 4	
			E	C	E	C	E	C	E	C
SMP N 1 Sluke	29	Performing an in-depth investigation of a problem.	44.8	54.3	70	68	71.6	70.7	84.5	75
		Carrying out detailed steps.	44	48.3	55.2	63.8	71.6	69.9	83.6	76.8
		Developing an idea.	39.7	48.3	50.8	51.7	65.5	62.9	80.2	71.6
		Revealing new possibilities.	40.5	45.6	56	57.8	75	69	81.9	76.7
SMP N 1 Pancur	31	Performing an in-depth investigation of a problem.	52.4	56.5	65.3	64.5	74.2	74.8	86.2	82.3
		Carrying out detailed steps.	52.4	54.8	64.5	62.9	74.2	74.2	85.5	80.6
		Developing an idea.	50.8	50	62.9	58.1	71	71.8	80.6	71.8
		Revealing new possibilities.	58.9	54	68.5	64.5	72.6	75.8	82.3	80.6

Table 4.1 shows an improvement in every indicator at each meeting, with the highest achievement in the indicator for performing an in-depth investigation of a problem. This high performance is attributed to integrated STEM-PjBL learning, which promotes group collaboration and encourages students to discuss information from their environment and existing technologies. This is parallel with Setari & Yuliawati (2024) who unveiled that integrated STEM-PjBL provides an engaging learning experience, as students can exchange ideas and

support each other when facing challenges, thereby actively participating in the learning process. Further, Silalahi et al. (2020) explained that integrated STEM-PjBL allows students to freely and smoothly explore and understand a problem from multiple perspectives based on their ideas. The STEM-PjBL model is a collaborative learning method that emphasizes active, group-based learning and information sharing, thereby broadening students' perspectives (Ralph, 2015).

Achievements in the experimental class were higher compared to the control class. This improvement is attributed to the implementation of integrated STEM Project-Based Learning (PjBL). Research by Mamamit (2020) and Nurmala et al. (2021) indicated that the STEM-PjBL model is more effective in enhancing creativity in the experimental class compared to the control class as the learning requires facilities that support enjoyable, engaging, and creativity-enhancing teaching and learning activities The high achievements across each elaboration skill indicator suggest that integrated STEM PjBL is effective in improving students' elaboration skills. These findings are further supported by Sylvia et al. (2020), who demonstrated that the STEM-PjBL model has a greater impact on skills than the PjBL model alone.

The influence of integrated STEM-PjBL on students' elaboration skills related to object movement and living creatures was examined using the T-test, Pearson correlation, and correlation coefficient. The T-test was employed to determine if there were significant differences in elaboration skills results due to the learning impact.

Table 4.2 The T-Test Analysis of Integrated STEM PjBL on the Materials of Object Movement and Living Creatures in Relation to the Attitude of Students' Elaboration Skills.

	N	Sig
SMP N 1 Pancur	62	0.008
SMP N 1 Sluke	58	0.000

Based on Table 4.2, the T-test analysis revealed significance values of 0.008 at SMP N 1 Pancur and 0.000 at SMP N 1 Sluke. Since the T-test results at both schools were $t \leq 0.05$, the alternative hypothesis (Ha) is accepted, and the null hypothesis (Ho) is rejected. The average difference between the scores of the experimental and control classes indicates that the application of integrated STEM-PjBL in teaching object movement and living creatures impacts students' elaboration skills positively. This finding is supported by Setari & Yuliawati (2024), who noted a difference in the enhancement of creative thinking abilities between integrated STEM-PjBL learning and conventional learning.

Table 4.3 The T-Test Analysis of Integrated STEM PjBL Impact on Students' Elaboration Skills in Object Movement and Living Creatures

	N	Sig
SMP N 1 Pancur	62	0.000
SMP N 1 Sluke	58	0.000

The T-test results at both schools were $t \leq 0.05$, leading to the acceptance of the alternative hypothesis (Ha) and the rejection of the null hypothesis (Ho). These results indicate a significant difference in elaboration skill scores between the experimental and control classes, attributed to the influence of the integrated STEM-PjBL application on the material of object movement and living creatures. This finding aligns with Pangestika et al. (2020), who reported a positive impact of the STEM-PjBL model on students' creative thinking abilities. Additionally, Cahyani et al. (2020) noted that STEM-based PjBL provides challenges and motivation for students, enhancing their elaboration skills.

Table 4.4 The Pearson Correlation Analysis Results

	N	R	Category
SMP N 1 Sluke	58	0.69	Strong
SMP N 1 Pancur	62	0.61	Strong

The Pearson correlation analysis reveals that integrated STEM-PjBL on the topics of object movement and living creatures at SMP N 1 Sluke and SMP 1 Pancur has a strong influence on students' elaboration skills. This approach enhances students' creativity and learning outcomes, demonstrating its effectiveness in meeting 21st-century educational goals. Rawung

(2021) asserted that teaching and learning activities must address the skills required for the 21st century, while Rahayu et al. (2022) emphasized that 21st-century learning impacts science and technology, influencing environmental life over time.

The coefficient of determination analysis results are presented in Table 4.5.

Table 4.5 The Coefficient of Determination Analysis

	N	R	CD (%)
SMP N 1 Sluke	58	0.80	64
SMP N 1 Pancur	62	0.85	72.72

The correlation coefficient measures the extent to which a model influences a dependent variable. At SMP N 1 Sluke, the Coefficient of Determination (CD) was 64%, indicating that integrated STEM-PjBL accounts for 64% of the impact on students' elaboration skills related to object movement and living creatures, with the remaining 36% attributed to other factors. At SMP N 1 Pancur, the CD percentage was 72.25%, suggesting that integrated STEM-PjBL explains 72.25% of the variation in elaboration skills, while 27.75% was influenced by other factors. These other factors may include environmental conditions, student engagement, and motivation.

Elaboration Skills Achievement Based on Student Questionnaires

The student questionnaire intends to assess the students' elaboration skills through self-evaluation. Administered at the final meeting of the teaching and learning process, the questionnaire was given to students in both control and experimental classes to measure the achievement of their elaboration skills. The results of this assessment are detailed in Table 4.6.

Table 4.6 The Elaboration Skills Based on Student Questionnaires

	N	The observed indicators	Experiment Achievement (%)	Description	Control Achievement (%)	Description
SMP N 1 Sluke	29	Performing an in-depth investigation of a problem.	79.3	Good	73.7	Good
		Carrying out detailed steps.	79	Good	72.8	Good
		Developing an idea.	75	Good	71.8	Good
		Revealing new possibilities	83.3	Very Good	77	Good
SMP N 1 Pancur	31	Performing an in-depth investigation of a problem.	79.4	Good	77.4	Good
		Carrying out detailed steps.	79.2	Good	75.8	Good
		Developing an idea.	75	Good	73.1	Good
		I am finding out more in-depth about a problem.	83.1	Very Good	79.4	Good

The student elaboration skills questionnaire includes 15 indicators based on student responses. The analysis revealed two levels of achievement: 'good' and 'very good.' At SMP N 1 Sluke, the highest achievement was in the indicator of expressing new possibilities, as students felt confident in proposing new ideas and questioning the validity of their concepts. This high achievement aligns with existing observation results.

Conversely, the indicator with the lowest achievement was developing an idea, observed in both the experimental and control classes, due to students' lack of confidence in expanding existing ideas. In the learning process, the students were tasked with developing theories by creating

products or solving problems. In the experimental class, the students developed ideas related to object movement and living creatures through mathematical problems or current technology examples. Integrated STEM-PjBL learning significantly influenced the achievement of elaboration skills in the experimental class, leading to superior results compared to the control class. The high level of elaboration skills achieved through integrated STEM-PjBL learning enhanced students' confidence to explore further and express their ideas.

The achievement of elaboration skills at SMP N 1 Sluke and SMP N 1 Pancur is nearly identical in the experimental classes. In contrast, the control class at SMP N 1 Pancur shows greater achievement than that at SMP N 1 Sluke. A lack of confidence in filling out questionnaires can influence the achievement of students' elaboration skills. This observation aligns with Mayang et al. (2022), who noted that elaboration involves diligent and careful work, while confirmation involves justification, affirmation, and validation. Integrated STEM-PjBL fosters students' creativity by allowing them to apply existing materials to daily activities, analyze and plan ideas, or present them as products (Ayuningsih et al., 2022).

The Implementation of Integrated STEM-PjBL

The implementation of integrated STEM-PjBL on the topics of object movement and living creatures was analyzed using student questionnaire data and teacher observations. The questionnaire was completed during the study's final meeting, while teacher observations assessed the implementation's achievement at each meeting.

The indicators observed included reflection, research, discovery, application, and communication, and the STEM-PjBL model encompasses these five stages of learning (Laboy, 2010). The results of the achievement analysis, based on the questionnaire data, are presented in Table 4.7.

Table 4.7 The Student Questionnaire Results on the Achievement of Integrated STEM-PjBL on the Subject of Object Movement and Living Creatures

The observed indicators	SMP N 1 Sluke Achievement (%)	Criteria	SMP N 1 Pancur Achievement (%)	Criteria
Reflection	80.7	Good	81.3	Very Good
Research	80.4	Good	81	Good
Discovery	78.7	Good	79.6	Good
Application	80.2	Good	80.1	Good
Comunication	81.7	Very Good	81.6	Very Good

Table 4.8 Teacher Observation Results on the Implementation of Integrated STEM-PjBL on the Subject of Object Movement and Living Creatures

The observed indicators	SMP N 1 Sluke Achievement (%)	Criteria	SMP N 1 Pancur Achievement (%)	Criteria
Reflection	100	Good	93.75	Very Good
Research	81.25	Good	81.25	Good
Discovery	81.25	Good	81.25	Good
Application	87.5	Good	87.5	Very Good
Communication	100	Very Good	100	Very Good

The integrated STEM-PjBL has a significant impact on the learning process related to object movement and living creatures. The achievement of integrated STEM-PjBL implementation was measured using student questionnaire data and teacher observation data. Analysis of the questionnaire data from SMP N 1 Sluke and SMP N 1 Pancur indicated that the

implementation of integrated STEM-PjBL has achieved 'Good' and 'Very Good' ratings. The highest achievement in the implementation of integrated STEM-PjBL at both schools was observed in the communication indicator, reflecting students' confidence in their ability to communicate effectively. Conversely, the lowest achievement was found in the discovery indicator, as students continued to struggle with problem-solving. The discovery stage is crucial in the integrated STEM-PjBL learning process, requiring students to solve problems, design products, and identify appropriate thematic formulas.

The achievement of Integrated STEM-PjBL implementation, as reported in student questionnaires, was further supported by teacher observations conducted at each meeting, where teachers were monitored by supervising educators throughout the study. The results of these observations categorized the implementation of Integrated STEM-PjBL as 'very good,' due to the effective execution of the PjBL learning framework by the teachers. Teachers are responsible for providing learning media, facilitating interactions between students, teachers, and learning resources, and actively engaging students. They play a crucial role in fostering students' creative and critical thinking skills as they analyze and solve problems during each activity. The highest achievement in the implementation of Integrated STEM-PjBL was observed in the communication indicator, which was consistent with the student questionnaire results. During the communication stage, a reciprocal relationship between teachers and students, as well as among students themselves, was established, allowing this indicator to be rated as 'very good.' Research by Supiase et al. (2023) indicated that high attractiveness ratings suggest students find the design of integrated STEM-PjBL and the Student Worksheets used to be engaging. Student activities during Integrated STEM-PjBL reflect a student-centred approach, which is in line with the designed PjBL syntax. As a student-centred learning method, PjBL requires students to be proactive and independent in tackling the tasks they encounter (Sari et al., 2023).

CONCLUSION

Based on the research results, this study concludes that Integrated STEM-PjBL significantly impacts elaboration skills regarding object movement and living creatures. Specifically, the influence of Integrated STEM PjBL on elaboration skills was measured at 64% at SMP N 1 Sluke and 72.25% at SMP N 1 Pancur.

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