

STEM-INTEGRATED PROJECT BASED LEARNING (PJBL) LEARNING TOOLS TO IMPROVE ELEMENTARY SCHOOL STUDENTS' CREATIVE THINKING SKILLS

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Abstract

Integrated STEM-based Project-Based Learning (PjBL) is an instructional approach designed by teachers to actively engage students in learning activities, aiming to enhance their creative thinking skills and stimulate the exploration of new ideas. This study aimed to analyze the feasibility, effectiveness, and practicality of STEM-integrated PjBL learning devices in improving the creative thinking skills of fourth-grade students at Santo Paulus Martubung Elementary School, Medan. The research employed a Research and Development (R&D) method. The findings indicated that the developed learning devices significantly improved students' creative thinking skills, as evidenced by an average n-gain score of 0.49, which falls into the moderate improvement category. Additionally, the devices proved effective in enhancing students' scientific literacy, with an average score of 0.64, also categorized as a moderate increase. The observed improvements included greater interest in science and technology, active participation in discovery-based activities (practices and projects), and a stronger sense of responsibility in managing natural resources and the surrounding environment. Therefore, the STEM-integrated PjBL learning devices are considered feasible, effective, and practical for use in primary education, supporting contextual learning that fosters students' creative thinking and scientific literacy.

Keywords: *learning devices, PjBL, STEAM, creative thinking skills.*

INTRODUCTION

Permendiknas No. 24 of 2016 states that learning in elementary schools needs to be given to students so that they have curiosity, honesty, logic, criticality, creativity, and discipline (Depdiknas, 2016). The ability to think creatively is a potential possessed by every human being (Ishak et al. 2017:92). The ability to think creatively is a person's ability to produce something new, either in the form of ideas or real works that are relatively different from those that have existed before (Noviyana, 2017:69). The ability to think creatively is one of the cognitive aspects that must be considered in the learning process (Antika & Nawawi, 2017:69). As the opinion can be concluded that the ability to think creatively is a person's ability to produce new ideas in an aspect of cognitive thinking in learning activities. The ability to think creatively can be developed through the Project-Based Learning (PjBL) learning model (Annisa et al. 2018:52). The PjBL learning model is a learning model that uses projects in core activities (Furi et al. 2018:104). In line with the above, it states that PjBL is a student-centered learning model and provides meaningful learning experiences to students (Afriana, Permanasari, & Fitriani, 2016:85). Students can learn through experience or concept acquisition built on the final product produced in learning. One of the products developed in education is integrated through Science, Technology, Engineering, and Mathematics (STEM).

STEM is an approach that involves students in metacognitive activities (Afifah et al. 2019:86). STEM is a discipline that is closely related to each other (Astuti et al. 2019:68). The STEM integration program in learning is a learning program that combines two or more fields of science contained in STEM—Science, Technology, Engineering, and Mathematics (Ismayani, 2016:79). STEM is a learning approach that provides opportunities for teachers to show students concepts, principles, science, technology, engineering, and mathematics integrated into the development of products, processes, and systems used in students' daily lives. STEM is an interdisciplinary approach to learning where students use science, technology, engineering, and mathematics in real contexts that connect school, work, and the global world. Thus, developing STEM enables students to compete in the new era (Listiana et al. 2019:86). STEM is important to be applied in 21st-century learning to provide learning experiences that can help

students face new challenges. So in this case, the ability of students through an approach can encourage them to be positive in academics so that they are trained to think creatively as demanded by the 21st century (Han et al. 2016; Mu'minah & Aripin, 2019:54). In line with the objectives of STEM, which prepare students for secondary science milestones and make students learn to apply and practice all situations that students face, especially in the 21st century (Fikri et al. 2019; Nuraziza & Suwarma, 2018:104). Through integrated STEM learning, at least it can provide opportunities for students to think creatively to face the challenges of the 21st century.

The learning process can be carried out through model stages that are integrated with approaches, one of which is the STEM-approach PjBL model (Afriana et al. 2016:34). STEM approach PjBL is integrated project-based learning in the STEM field that can provide opportunities for students to learn contextually, such as exploring planning learning activities, implementing projects collaboratively, and ultimately producing a product (Jauhariyyah et al. 2017:73). PjBL-STEM is a project-based learning model that has the criteria of science, technology, engineering, and mathematics (Annisa, 2018:83). STEM-approach learning encourages students to have a positive attitude in academics. So it can be concluded that the relationship between science and technology and other sciences cannot be separated in learning. Science requires mathematics as a tool in processing data, while technology and engineering are applications of science. The STEM-integrated PjBL learning model is a learning context designed by teachers to encourage students to be directly involved in learning activities (Siew et al. 2015:85). So that it has the function of improving the ability to think and explore emerging ideas. This is proven based on the results of previous studies stating that the project-based learning model based on STEM learning can improve students' creative thinking skills (Lestari, Sarwi, & Sumarti, 2018:54). The PjBL model can affect students' learning motivation, creativity, critical thinking skills, and cognitive abilities (Insyasiska et al. 2015). Through the STEM approach, students' creative thinking skills can be improved (Almuharomah et al. 2019:73). Project-based learning can improve creative thinking skills, including aspects of fluency, originality, elaboration, and flexibility (Suryandari et al. 2016:27).

Based on the results of unstructured interviews with ten fourth-grade teachers in the Medan Labuhan sub-district, information was obtained that in implementing learning, they found it difficult to develop learning and the lack of variety of learning models used in learning activities. So in this case, the researcher will develop related learning devices; the existence of learning activities actually begins with the creation of learning devices, including syllabuses, lesson plans, textbooks, and supporting practice questions. The level of student understanding of the subject matter is still low. This can be seen in examples of student practice questions on learning themes that tend to measure abilities in the LOTs-MODs category. The presentation of questions tends to be on the cognitive aspects of students about remembering, mentioning, completing, and simple explanations. Students' thinking abilities need to be improved again through the development of learning devices, including syllabuses, lesson plans, student books, and creative thinking ability test questions in science learning. Observations made that classical completeness at SD Santo Paulus Martubung-Medan, which was to be studied, had not reached 50% with the results of the final semester assessment (PAS) in class IV, where the students' science scores were still relatively low with the minimum completeness criteria (KKM) of 70; only 11 students, 28.20%, achieved KKM, and 28 students, 71.79%, had not achieved KKM. SD Santo Paulus Martubung Medan only had 7 students, 35%, achieve KKM, and 13 students, 65%, had not achieved KKM. Researchers see from the existing problems that there will be a development related to learning devices, namely the development of STEM-integrated project-based learning devices. Students are expected to be able to understand the material in the student's book and motivate teachers to use and develop interesting learning devices that are in accordance with the needs of environmental conditions, both from the perspective of students and teachers, in order to have updates in implementing learning activities.

The development of STEM-integrated PjBL learning devices based on e-learning is expected to improve students' creative thinking skills in learning energy sources. The researcher intends to develop a product on "Development of Integrated STEM Project-Based Learning (PjBL) Learning Devices to Improve Students' Creative Thinking Skills.". The formulation of the problem in this study, among others, is: (1) Is the STEM-integrated PjBL learning device suitable for use to improve students' creative thinking skills? (2) Is the STEM-integrated PjBL learning device practical to use to improve students' creative thinking skills? (3) Is the STEM-integrated PjBL learning device effective for improving students' creative thinking skills?.

METHOD

This type of research is research that uses the Research and Development (R&D) development model. This development research was conducted at Santo Paulus Martubung Elementary School-Medan in Class IV of Elementary School in the 2023/2024 academic year. This investigation took place in December 2023. In this research process, a research instrument is needed to observe plant morphology, consisting of instrument tools and materials and plant morphology indicators

Table 1. Research Tools

No.	Tool name	Usefulness
1.	Stationery	To record observation results
2.	Knife	To cut the required sample parts
3.	White manila paper	For background photos of observed samples
4.	Camera	To document research results
5.	Plant morphology book	For guidance and reference in the characterization proces

Table 2. Percentage Scale According to Arikunto (1996: 244)

Percentage of Ideality (%)	Criteria
$76\% \leq \text{score} \leq 100\%$	Very feasible
$51\% \leq \text{score} \leq 75\%$	Feasible
$26\% \leq \text{score} \leq 50\%$	Quite Feasible
$0\% \leq \text{score} \leq 25\%$	Less Feasible

Interpret the data based on the following table:

$$\text{level of practicality} = \frac{\text{Total Score Obtained}}{\text{Total Highest Score}} \times 100\%$$

Table 3. Interpretation of Learning Device Practicality Data

Percentage of Ideality (%)	Criteria
$80 \leq V \leq 100$	Very Practical
$60 \leq V < 80$	Practical
$40 \leq V < 60$	Quite Practical
$20 \leq V < 40$	Less Practical
$0 \leq V < 20$	Not Practical

The developed learning device is categorized as practical with a minimum ideal percentage in the practical criteria, namely at an ideal percentage of $60 \leq V < 80$. The effectiveness of the developed science learning device is determined from the difference in the average posttest in the experimental class and the average posttest in the control class. The results of the posttest will be tested for normality, homogeneity, and t-test to determine its effectiveness. The type of research that researchers will use To find out how well the product works, we will use a type of research called quasi-experimental, which compares a group that uses the product with a group that does not, and we will only test them after using the product. This design looks at the experimental group and the control group side by side. The design summary can be seen in table 4.

Table 4. The Nonequivalent Posttest-Only Control Group Design

X	O
Provision of learning devices Control	Posttest to measure students' final abilities
STEM-based PjBL learning devices	Posttest to measure students' final abilities

Description:

X = Treatment given (independent variable)

O = Posttest (observed dependent variable)

The t-test is a method used to check if there is a meaningful difference between the averages of two groups we are comparing. Before using the t-test to look at data, you need to check two things: first, the normality test, and

second, the homogeneity test. The normality test checks if the samples in the study are spread out in a typical way. The normality test used is called the Kolmogorov Smirnov test. If the significance value is greater than 0.05, it means the data is normally distributed. Homogeneity Test: This is a statistical test used to check if two groups of samples have the same level of variation. In this study, we checked for similarity by comparing the data from the experimental group and the control group. Testing for similarity using the Levene test with the SPSS 23 program. If the initial data calculation produces $F_{\text{count}} < F_{\text{table}}$, then the sample is said to have the same variance or homogeneous. The F_{table} is obtained by first determining db numerator and db denominator. The value of db numerator = $n - 1$ and db denominator = $n - 1$. With a significance level of 5%. To test the effectiveness hypothesis, the t-test formula is used as follows.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{s^2 \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

The statistical hypotheses tested are: For the feasibility of learning devices

Ho: $\mu < 3.0$ assumed not feasible ; Ha: $\mu \geq 3.0$ assumed feasible

For the effectiveness of Learning Devices

Ho: $\mu_1 \leq \mu_2$ assumed not Effective ; Ha: $\mu_1 > \mu_2$ assumed Effective

For the Practicality of Learning Devices

Ho: $\mu < 60$ assumed not practical ; Ha: $\mu \geq 60$ assumed practical

Where:

μ_1 = Average creative thinking ability of the experimental class

μ_2 = Average creative thinking ability of the Control class

RESULTS AND DISCUSSION

The assessment of learning devices by practitioners was carried out by class teachers and grade IV elementary school students. The PjBL model learning devices integrated with the STEM approach developed were assessed by two teachers of Santo Paulus Martubung Elementary School - Medan. Aspects assessed by grade IV teachers and colleagues included the format of the learning device, material/content, language learning process, and assessment. "The results of the assessment by grade IV teachers can be seen in table 5.

Table 5. Results of assessment of Learning Devices of the PjBL model integrated with the STEM approach by grade IV teachers and peers

No. Code	Indicator Assessment	Score	Criteria
1 – 2	Learning Device Format	3,5	Very Practical
3 - 9	Learning Material	3,71	Very Practical
10 – 14	Learning Process	3,67	Very Practical
15 – 17	Language	3,50	Very Practical
18 – 20	Assessment	3,83	Very Practical
	Average	3,68	Very Practical

The assessment of LKPD by grade IV elementary school students was conducted by giving a questionnaire to 26 grade IV students of Santo Paulus Martubung-Medan Elementary School". The questionnaire contained statements categorized into four aspects, namely learning activities, appearance, language, and availability of space/instructions. "The results of the assessment by grade IV elementary school students can be seen in table 6.

Table 6. Results of LKPD assessment by grade IV Elementary School students

No. Code	Indicator Assessment	Score	Criteria
1 - 3	Learning Activities	3,68	Very Practical
4 - 5	Appearance	3,51	Very Practical
6 - 8	Language	3,20	Practical
9 - 10	Availability of room/instructions for use	3,33	Practical
	Average	3,43	Very Practical

How well learning tools help improve creative thinking skills. The assessment results are shown in Table 7.

Table 7. Data on creative thinking skills in control and experimental classes

Problem Solving Skills

No	Description	Control Class		Experimental Class	
		Pretest	Posttest	Pretest	Posttest
1	Minimum	40,00	52,00	27,50	57,00
2	Maximum	82,00	82,50	100,00	100,00
3	Mean	61,00	72,77	68,07	81,52
4	Std. Deviation	12,12	8,35	16,93	14,58

The parametric prerequisite test in this study began with a normality test. The normality test of creative thinking ability used Kolmogorov-Sminov. The results of the normality test can be seen in table 8.

Table 8. Normality Test Results

		Kolmogrov-Smirnov ^a			Shapiro-Wilk		
	KPM Class	Statistic	df	Sig.	Statistic	df	Sig.
KPM Pretest Results	Experiment	.125	21	.200*	.965	21	.615
	Control	.117	20	.200*	.960	20	.536

From table 8, readers can see that the sig value in both the experimental class and the control class is 0.200, which is greater than 0.05. These results show that the two classes think creatively in different ways. Also, it can be understood that the questions about creative thinking skills in this study follow a normal distribution.

Table 9. Homogeneity Test Results

Levene Statistic	df1	df2	Sig.
1.491	1	39	.229

Data is called homogeneous if the significance level is consistent. value is greater than 0.05. From table 16, we can see that the importance value of creative thinking ability is 0.229, which is greater than 0.05. The data indicates that the control and experimental classes have similar levels of variation. The researcher made a conclusion by looking at the data from tests on normality and homogeneity related to problem-solving skills. Parametric tests can only be done if the data is normal and homogeneous. In this study, we used an independent sample t-test, which is a type of parametric test. The sample t-test is used to find out which class helps students improve their creative thinking skills more. Classes that use integrated project-based learning devices with the STEM approach or classes with other learning model devices. Readers can see the differences between the two classes in table 10.

Table 10. Independent sample t test results

Leven's Test for Equality of Variances				t-test for Equality of Means					
		F	Sig.	t	df	Sig.(2-tailed)	Mean Difference	95 % Confidence Interval of the Difference	
KPM Results	Equal variances assumed	6.45	.015	2.34	39	.024	8.75	1.19	16.31
	Equal variances not assumed			2.37	32.11	.024	8.75	1.23	16.26

After The independent sample t-test was done, and here are the important results. The ability for creative thinking had a score of 0.024 on a two-tailed test. This value is less than 0.05. This value means that there is a difference in creative thinking ability between classes that implement PjBL-based learning devices integrated with the STEM approach and classes that do not implement it. The strong effect seen between the control class and the experimental class shows that using the PjBL learning model combined with the STEM approach helps improve students' creative thinking skills. The amount of improvement can be seen in the n-gain score in table 11.

Table 11. Creative Thinking Ability Data

Class	Creative Thinking		Skor <i>n-gain</i>	Category
	Pretest	Posttest		
Control	61.00	72.77	0.26	Low
Experiment	68.07	81.52	0.49	Medium

The *n-gain* score of creative thinking ability is 0.26 for classes that do not use the developed learning tools and 0.49 for classes that do. The control class score is categorized as low, The experimental class is in the middle level. The *n-gain* scores are not the same in the two classes.

Table 12. Results of Assessment of Material Aspects of Elementary School Science Experts

No. Code	Indicator Assessment	Score	Criteria
1 – 7	Technique Feasibility/Correctness of Material	2,57	Feasible
8 – 13	Presentation of Material	3,33	Very Feasible
14 – 15	Language	3,00	Feasible
16 – 18	Suitability of Evaluation Form	1,67	Very Less Feasible
Average		2,76	Feasible

Table 13. Results of the RPP Feasibility Assessment by Learning Devices experts

No. Code	Indicator Assessment	Score	Criteria
1 – 6	Quality of learning objectives	4	Very Good
7 – 22	Quality of content	3,81	Very Good
23 – 25	Quality of language	3,70	Very Good
Average		3,84	Very Good

Next is the assessment of the feasibility of LKPD by learning device experts. The assessment of the feasibility of LKPD is reviewed from the quality of content, didactic feasibility, technical assessment, and construction. The results of the LKPD feasibility assessment can be seen in table 14.

Table 14. Results of LKPD Feasibility Assessment by Learning Devices experts

No. Code	Indicator Assessment	Score	Criteria
1 – 7	Content quality	3,71	Very Feasible
8 – 12	Didactic feasibility quality	3,60	Very Feasible
13 – 19	Technical Assessment	3,57	Very Feasible
20 – 25	Construction	3,67	Very Feasible
Average		3,64	Very Feasible

"Experts check if the teaching materials can be used with learning devices. " "We check how good the teaching materials are based on their content, how they are presented, the language used, and the images". The results of the evaluation of teaching materials can be seen in table 15.

Table 15. Results of the assessment of the feasibility of Teaching Materials by Learning Device Experts

No. Code	Indicator Assessment	Score	Criteria
1 – 9	Content quality	3,62	Very Feasible
10 – 16	Presentation feasibility quality	3,71	Very Feasible
17 – 20	Language	3,75	Very Feasible
21 – 28	Graphics	3,78	Very Feasible
Average		3,71	Very Feasible

The use of LKPD model PjBL integrated with STEM approach in learning activities is applied to the experimental class consisting of 21 students". Student responses to the use of LKPD model PjBL integrated with STEM approach "Based on the graph in Figure 7, it can be explained that as many as" 76% (16 students) strongly agree with the use of LKPD model PjBL integrated with STEM approach in thematic learning, 24% agree (5

students)". "Based on these results, it can be concluded that students responded positively to the development of LKPD model PjBL integrated with STEM approach".

Discussion

The product development in this study is in the form of project-based learning devices combined with a Science, Technology, Engineering, and Mathematics (STEM) approach to the material 'Caring for the Environment. The purpose of developing the product is to improve the creative thinking skills of fourth-grade elementary school students. The researcher used a research and development model that has important components in the process of creating instructional design, namely: (1) the stage of finding obstacles in the field, analyzing each aspect of learning, and determining the product; (2) the product design stage; (3) the product manufacturing stage; and (4) the advanced stage to distribute the product on a wide scale (Thiagarajan et al. 1974: 5). According to material experts, the learning devices developed in terms of content and presentation of the material are good, but the evaluation given or included in the learning devices has not been able to involve students in challenging activities. Meanwhile, learning device experts wrote that the learning devices developed are good in terms of format, completeness, accuracy of content, and presentation in LKPD and teaching materials that attract students with the presence of colored pictures included in the material.

Based on these results, it can be concluded that students are interested in the learning activities implemented, so that students' interest in science and technology also increases. While it seems that some students have not been able to reflect an attitude of responsibility towards the surrounding environment as expected. "The integrated PjBL learning device with the STEM approach is effective in improving science literacy because it presents various materials and learning project activities that are packaged in an attractive way, both in the form of text, images, and videos". One aspect assessed in science literacy is the aspect of interest. The learning device in this case is LKPD, which is arranged systematically, attractively, and easily understood to foster students' positive attitudes towards learning. Not only that, this is supported by the theory of situational interest (Hidi & Baird, 1988: 469), which states that environmental quality in this case can be in the form of good facilities and infrastructure that can foster student interest. For example, fourth-grade elementary school students will be interested in learning something if the teacher creatively displays varied learning activities, using interesting media in the classroom.

Students who are more often accustomed to scientific activities tend to be more capable and able to solve problems in simple or complex forms "This is supported by the use of the integrated PjBL model with a STEM approach that involves the use of technology as part of classroom learning." It is undeniable that students in the modern era today prefer learning that uses technology. The resulting impact is also said to be good for developing creative thinking as a requirement for being able to solve problems. Meanwhile, scientific literacy, which includes aspects of attitudes, can be improved through scientific activities such as conducting experiments (Ainley et al., 2002: 424-425). Scientific literacy consists of aspects of knowledge, skills, and attitudes. One aspect of attitude in the achievement of scientific literacy is interest (Hidi, 1990: 553)". Mursid, R. et al. (2022) stated that improving learning outcomes is very helpful in achieving quality science and knowledge in the field, problem solving, developing interests and talents, as well as the application of technology in the 21st century in the ability to think creatively through the application of holistic and effective learning strategies.

These scientific activities can also attract students' interest in learning. With the interest or attraction to learning, students are more enthusiastic and focused and strive to understand the learning (Hidi & Renninger, 2006: 113). "Fundamentally, integrated project-based learning devices in the four-scientific approach (science, technology, engineering, and thematic) that are developed are not only intended for students' skills in solving problems and scientific literacy attitudes but also make it easier for teachers to design learning that involves students in scientific activities. Moreover, the integrated PjBL learning device with the STEM approach supports students' learning independence effectively". "They can learn in different ways through simple practice and project creation. It is common in research that every study certainly has limitations among the existing advantages. Some of the advantages that can be considered are: (a) the suitability and completeness of the material presented in teaching materials and LKPD make it easier for students to develop skills and knowledge; (b) providing creative and varied learning; (c) students can do many practical activities and projects with teacher guidance that can help students develop scientific literacy and problem-solving skills; (d) teachers and students are directly involved in problem-solving, practice, and project creation activities.

CONCLUSION

The conclusions that can be put forward are as follows:

1. The learning devices developed, especially LKPD and teaching materials, are considered feasible in terms of appearance and presentation techniques. Experts and teachers stated that the devices developed are feasible and easy for students to understand.
2. The learning devices developed on the material 'Caring for the Environment' practically increase students' scientific literacy significantly.
3. The learning devices developed have proven to be effective in increasing students' creative thinking skills significantly. The increase in creative thinking skills can be seen from the average n-gain score of 0.49 (moderate increase category).

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