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The effectiveness of portfolio assessment based problem based learning on mathematical critical thinking skills in elementary schools

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ABSTRACT

This study aims was determine the effectiveness of the problem-based learning model based on portfolio assessment on the ability to critical thinking in mathematics. The research sample was 120 elementary school students in South Kalimantan. sampling was used multistage cluster sampling technique. This research was a quasiexperimental research. Data analysis was performed used a two-way ANACOVA test. The results showed that (1) Problem based learning had an influence on students' critical thinking skills in mathematics because the F_{count} obtained was 6.351 compared to F_{table} (0.05< 1.115), which was 3.93. (2) it was said that there was a significant influenced between the interaction of learning models and assessment techniques on students' critical thinking skills in mathematics because the F_{count} obtained was 25.669 compared to F_{table} (0.05< 1.115), namely 3.93. (3) it was not true that the portfolio assessment technique has a significant effect on students' mathematical critical thinking skills. The F_{count} obtained was 1.476 compared to F_{table} (0.05>1.115), which was 3.93. Judging from the value of sig. (0.227) > α (0.05)

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1. INTRODUCTION

Assessment is a general term covering the procedures used to obtain information about student learning (observation, implementation of written tests, averages) and the format of assessment of learning progress (Alrahlah, 2016). One of the assessment techniques that can be carried out by educators in the process of learning activities to help students in learning activities is to use portfolio assessment (Broatfoot, et al., 2019). Portfolio assessment provides broad opportunities for students to demonstrate what they have learned and mastered during the learning process, but portfolio assessment is rarely used by teachers (Altintas et al, 2017). In learning mathematics students are required to think systematically, logically, analytically, creatively, and critically and have the ability to solve a problem not only in the field of mathematics but also in other fields of science in everyday life (Talib & Kailani, 2019). Critical thinking skills will grow in a person, if in the learning process in the classroom interaction and communication can be created that actively involve students in the formation of knowledge. The more often students are trained to think critically during the learning process in class, the more knowledge, experience, and problem solving in solving problems inside and outside the classroom (Tarmali, 2017).

Critical thinking is very important for students, a student can understand the condition of an area with existing constraints, this obstacle can be overcome if in the process of critical thinking students have awareness in creating, guiding, and measuring what is learned. Students who have critical thinking skills can consider various things in depth before making a decision to solve a problem in their environment (Setiadi, 2016; Boulton, 2018). The results of Mazumder's research (2019) state that one of the main goals of the school is to form students' critical thinking skills and one of the subjects that is considered to teach critical thinking skills is mathematics. Problem-based learning is focused on problems where students can construct their own knowledge, develop inquiry and thinking skills to a higher level. Students must be able to formulate temporary answers to a problem that requires logical intelligence, courage and active solutions to real situations. Students also need to increase independence, confidence and endurance to solve problems (Talib and Kailani, 2019). According to Javed et al. (2018) one way to create active learning is to apply a problem-based learning model.

The problem-based learning model (PBL) is useful for stimulating students' critical thinking in problem-oriented situations, encouraging students to apply critical thinking, problem-solving skills, connecting knowledge about problems and real-world problems, (Helen, 2018). Based on the initial information and observations as well as the results of the research in the first stage it was found that many students had difficulty learning mathematics, the assessment given by the teacher was only from the cognitive aspect, in the form of daily test assessments, formative tests, and summative, while the non-cognitive aspects had not been carried out in learning process with reasons considered a waste of time, effort, and many curriculum targets that must be completed within a predetermined time limit. The assessment given does not get appropriate feedback, if the assignment is returned it is only given initials and a score on the correct answer and red strokes on the wrong item, without correcting the error.

The teacher carrying out learning activities is still oriented towards achieving the target material contained in the curriculum, and prefers to use the time to provide practice questions in the student worksheets compared to training students to complete the exercises at a higher level thinking level, in this case less train critical thinking skills. In connection with these problems, teachers need to develop innovative learning models including the Problem Based Learning model. The Problem Based Learning model provides benefits in learning activities where learning is more student-centered, learning is more active and meaningful and can improve students' critical thinking skills (Alrahlah, 2016). Critical thinking skills can be implemented properly using a problem-based learning model so that it can improve students' critical thinking skills in elementary school mathematics. Mathematics is one of the basic abilities that students must have, from the early childhood education level, elementary, junior high to tertiary institutions (Chin and Chia, 2019). Mathematics is a branch of knowledge that students in elementary school must have, but often experience difficulties, especially in the problemsolving domain (Ati, 2020). But unfortunately mathematics has always been a frightening specter for students, due to their perception that mathematics is a difficult subject

This study aims to improve the quality of education, especially in elementary school education by conducting practicality tests to determine the effectiveness of learning and assessment tools so that an increase in teacher knowledge and mastery is obtained in carrying out meaningful, effective and efficient learning activities on mathematical critical thinking abilities after controlling initial knowledgeA title of article should be the fewest possible words that accurately describe the content of the paper. Indexing and abstracting services depend on the accuracy of the title, extracting from it keywords useful in cross-referencing and computer searching. An improperly titled paper may never reach the audience for which it was intended, so be specific.

2. RESEARCH METHOD

The research method used in this study was a quasi-experimental method with a 2x2 factorial design with two 2x2 categories (Creswell, 2013. The variables in this study consisted of the dependent variable and independent variable, the dependent variable (Y) is mathematical critical thinking skills using

posttest only, non-equivalent control group design, the dependent variable is only measured once, after the experiment is completed. While the treatment variable is the learning model (A), accompanied by the variable (B), namely the assessment technique. The learning model tested was the Problem Based Learning (A1) learning model, and the Expository learning model (A2), while for the treatment variable (B), the portfolio assessment technique (B1) and Written Test (B2) were selected, the control variable in this study is the initial knowledge of students (X).

The experimental design used is a 2 x 2 factorial design with the constellation as shown in the table below. This study involved controlling students' prior knowledge (X) as a covariate with the dependent variable namely mathematical critical thinking skills (Y).

Table 1. Factorial Design 2 x 2

Learning Model (A) Assesment (B)	Problem Based Learning(A1)	Expository learning (A2)
	(X,Y) 11k k=1,2,...,n11	(X,Y) 2 1k k=1,2,...,n21
Portfolio (B1)	(A_1 B_1)	(A_2 B_1)
Paper and Pencil Test (B2)	(X,Y) 12k k=1,2,...,n11A_1 B_2	(X,Y) 2 2 k k=1,2,...,n2 2A_2B_2

Information

A1 : Groups of students who follow the Problem Based Learning learning model
A2 : Group of students who follow the learning model Expository
B1 : Group of students who are given a portfolio assessment.
B2 : Group of students who are given a paper and pencil test
X : Student's initial knowledge
Y : Mathematical Critical Thinking Skills
A1B1 : Group of students who follow the Problem Based Learning Learning and portfolio assessment
A2B1 : Group of students who took the Expository Model and portfolio assessment
A1B2 : Group of students who follow the Problem Based Learning Model and a paper and pencil test
A2B2 : Groups of students who take the Expository Learning Model and written tests

This research was conducted at Cindai Alus 02 primary school, Banjar Regency, South Kalimantan. The preparation of this research plan starts from April to November 2022. The implementation of learning begins at the beginning of the odd semester of 2022. The research sample is part of the population according to the research design, sampling using the Multistage Cluster Sampling technique,

The stages of activity include: (a). find out the equality between classes in the population, to find out whether there are differences in the average initial knowledge of students before the experiment is carried out, (b). After it was believed that all classes were homogeneous, then the treatment class and control class were determined randomly by lottery, by selecting 4 (four) classes to be treated, 30 people each, a total of 120 people. After the 4 (four) classes received different treatment, two experimental classes and two control group classes with 30 students in each class. At the end of the lesson, a description test is given to determine critical thinking skills in mathematics

Table 2 Distribution of samples in each class

LearningModel Assesment	Problem Based Learning (A_1)	Expository Learning (A_2)	Summary
Portfolio (B1)	30	30	60
Paper and pencil test (B2)	30	30	60
Summary	60	60	120

The treatment variables in this study are classified into two, namely learning models and assessment techniques. The learning model is divided into two, namely the Problem Based Learning and Expository models, while the assessment technique is divided into two, namely the Portfolio assessment technique and written tests, according to the 2 x 2 factorial design in table 2 So there are 4 different treatment groups, (1). Groups of students using Problem Based Learning learning

accompanied by portfolio assessment techniques (A1B1), (2). Groups of students who use learning use Problem Based Learning learning accompanied by a written test (A1B2), (3). The group of students who used expository learning was accompanied by a portfolio assessment (A2B1), and the group of students who used expository learning (A2B2), was accompanied by a written test.

Testing of the analysis requirements is carried out with the help of the SPSS program. Prerequisite analysis tests carried out included: (1) test for normality of data distribution using the Kolmogorov-Smirnov test and Shapiro-Wilk test, (2) test for homogeneity of variance using the ANOVA test, (3) linearity test using the ANOVA test between groups with respect to the line deviation from linearity. Hypothesis testing uses two-way covariate analysis or usually known as two-way ANACOVA. The SPSS computer program is used to perform the calculations. The variables involved in the calculation include: (1) students' critical thinking skills (Y) as the dependent variable, (2) students' prior knowledge (X) as a covariate, (3) learning model (A) as an independent variable, consisting of: learning model problem based learning (A), and expository learning model (A2), (4) type of assessment (B) as an independent variable, consisting of: portfolio assessment (B1) and written test (B2).

The results of the two-way ANACOVA on data on students' Physics problem-solving abilities by controlling students' prior knowledge can be seen in Figure 4.4. The results shown are used to draw conclusions about the effect of the learning model (A) on students' mathematical problem-solving abilities and conclusions about the effect of types of assessment (B) on students' mathematical problem-solving abilities (Y) by controlling students' prior knowledge (X). Homogeneity testing was carried out with the help of the SPSS computer program through the Anova test. The steps taken include: clicking "analyze" then "compare means" followed by "one-way ANOVA". By paying attention to the row "between groups" the result is F = 1.600 with df = 3 and 116; price Sig. obtained 0.193. This is supported by the value of Sig. > 0.05, it can be concluded that the students' initial knowledge data between groups is classified as homogeneous. The normality test shows class A1 is sign. 0.200 and A2 are signs. 0.179. That is, both classes have normal data so that further tests can be carried out to test the level of effectiveness.

To measure students' prior knowledge, a test was used which consisted of 26 questions in the form of multiple choice answers. The correct answer will be given a score of 1 and the wrong answer will be given a score of 0. The test is first tested to find its validity and reliability. Validity was carried out using the bisireal point correlation formula of the 25 questions developed, there were 4 instruments that did not meet the validity requirements or were dropped and 22 items were declared valid. While the reliability of the instrument is calculated using the Kuder-Richardson-20 (KR-20) formula. Calculation of reliability of 0.826.

Testing the significance of the regression equation was carried out with the help of the SPSS computer program. The results of the regression analysis show the F value and significance. The criteria for testing the significance of the regression line equation are by looking at the Regression line in the ANOVA table. This can be done by comparing the F table values or comparing the significance value with the established criteria, in this test a = 0.05 was chosen. So if Sig. > a, then Ho is accepted or the regression is meaningless, otherwise if Sig. ≤ a then H1, accepted or significant regression.

Using the help of the SPSS computer program, the regression weight can be calculated by "analyze", selecting "regression" then "linear". Regression results can be seen from the sig. namely 0.001, this value is less than 0.05 so that it can be concluded that the regression equation means, with a value of R = 0.387 and F = 20.845. The criteria for testing the alignment of the regression line are done by comparing the F value with the F table or comparing the significance value with the established criteria. In this test, a = 0.05 is chosen, if Sig. ≥ a, then Ho is accepted or the regression line is parallel. Conversely, if Sig. <a, then H1 is accepted. The results of the analysis as shown in the Figure 1.

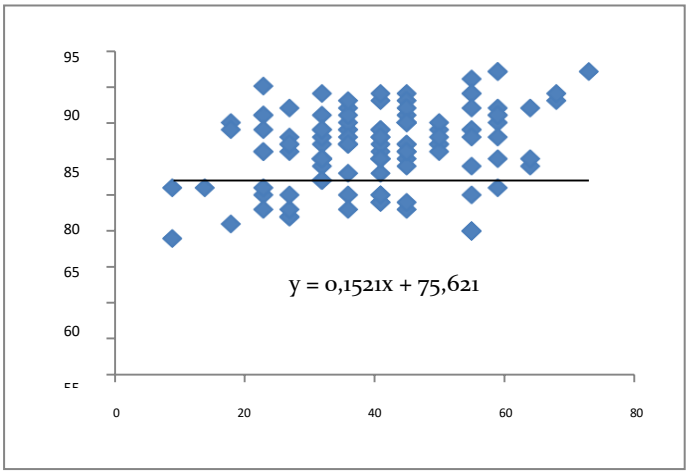

Figure 1. Regression Line Alignment Test Results

3. RESULTS AND DISCUSSIONS

First hypothesis: "The average critical thinking skills of students who take part in the problem-based learning model are significantly higher than the average critical thinking skills of students who take part in expository learning, after controlling for students' initial knowledge." Based on the results of the analysis as shown in Figure 2 it can be determined the effect of the learning model on students' critical thinking skills in mathematics by paying attention to row A. The Fcount value obtained is 6.351 compared to Ftable (0.05; 1:115) which is 3.93. It is concluded that Fcount > Ftable So that Ho is rejected and H1 is accepted. In addition, it can also be seen with the sig. (0.013) < α (0.05) so it can be said that the learning model (A) has an effect on mathematical critical thinking skills (Y). In other words, there is an average difference in students' mathematical critical thinking skills due to the influence of the learning model.

Tests of Between-Subjects Effects

Dependent Variable: PA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	738.395[a]	56	13.186	3.311	.000	.746
Intercept	5887.310	1	5887.310	1478.252	.000	.959
A	.007	1	.007	.002	.966	.000
B	615.905	35	17.597	4.419	.000	.711
A * B	107.357	20	5.368	1.348	.184	.300
Error	250.905	63	3.983			
Total	10388.000	120				
Corrected Total	989.300	119				

a. R Squared = .746 (Adjusted R Squared = .521)

Figure 2. ANACOVA Result

Acceptance of this hypothesis is also supported by data in figure 2 which shows the average score of students following the problem-based learning model of 36.27 with a standard deviation of 17.671. As well as the average score of students taking the expository learning model of 29.15 with a standard deviation of 14.227. Thus, it can be concluded that the average critical thinking skills of students participating in problem-based learning is significantly higher than the average the average mathematical critical thinking skills following expository learning, after controlling for students' prior knowledge.

Second Hypothesis: "The average critical thinking skills of students who received the portfolio assessment technique were significantly higher than the average critical thinking skills of students who received a written test, after controlling for students' prior knowledge. Based on the results of the analysis as shown in figure 2, it can be determined the effect of the assessment technique on students' critical thinking skills in mathematics by paying attention to row B. The Fcount value obtained is 1.476 compared to Ftable (0.05:1:115), which is 3.93. Judging from the value of sig. (0.227) > α (0.05) it can be said that it is not true that the assessment technique (B) has a significant effect on students' critical thinking skills in mathematics (Y). In other words, there is no difference in the average students' mathematical critical thinking skills due to the influence of assessment techniques. Figure 2 shows the average value of students who take part in learning by providing portfolio assessment techniques of 33.93 with a standard deviation of 17.490. As well as the average value of students who take part in learning by giving a written test of 31.48 with a standard deviation of 15.214. Thus, it can be concluded incorrectly that the average mathematical critical thinking skills of students who receive portfolio assessment techniques are significantly higher than the average critical thinking skills of students who receive written tests, after controlling for students' prior knowledge.

Third hypothesis: "There is an interaction effect between the learning model (A) and the assessment technique (B) on students' critical thinking skills in mathematics, after controlling for the effect of students' prior knowledge". students' mathematics by paying attention to row A*B. The obtained Fcount value is 25.669 compared to Ftable (0.05; 1;115) which is 3.93. The conclusions obtained are Fcount > Ftable so that H0 is rejected and H1 is accepted. In addition, judging from the sig. (0.000) < α (0.05) so it can be said that there is a significant influence between the interaction of learning models (A) and assessment techniques (B) on students' critical thinking skills in mathematics (Y). In other words, there is a difference in the average students' mathematical critical thinking skills due to the influence of the interaction of learning models with assessment techniques, after controlling for students' prior knowledge.

In general, this study aims to investigate the effect of learning models and techniques for assessing critical thinking skills in mathematics after controlling for students' prior knowledge. To limit the research, problem-based learning and expository learning models were selected as the first independent variables. As the second independent variable, an assessment technique was chosen which consisted of a portfolio assessment technique and a written test.

The test results show that the learning model variables (A) and assessment techniques (B) have a significant effect on mathematical critical thinking skills (Y) after controlling for students' prior knowledge. Through problem-based learning, each student plays an active role in learning because in this learning model all students are given the responsibility to be able to achieve common goals. In accordance with the opinion of Altintas & Ilgün (2017) the characteristics of Problem Based Learning are that it starts with the teacher giving problems to students related to everyday life or real life, further learning in groups and formulating problems and identifying according to their respective knowledge, students learn, looking for material, and looking for solutions to a problem. The problem-based learning model emphasizes learning by doing, meaning that students are invited to play an active role in learning, the teacher gives freedom to students to solve mathematical problems, as students are used to solving critical teaching independently. (Dominique, 2019; Jegger et. Al, 2019).

Whereas in expository learning, the teacher provides a lot of information in the form of lectures, while only a few students are involved, so that it can be said that learning is passive. To be able to carry out expository learning, teachers must know many things and be able to convey all the information needed by students to achieve learning objectives. According to Mustofa and Hidayah (2020), expository learning tends to create passive students, they only hope to receive information and imitate it in a number of ways. Several studies support that if students are actively involved in the learning process, student learning outcomes, one of which is critical thinking skills in mathematics as discussed in this study, will be better than students who only take part in a passive learning process. The research is in line with the results of the study concluded that the application of the problem based

learning model is better than the expository module in improving students' systematic reasoning abilities. (Rahman et al., 2017)

Portfolio assessment as explained in the theoretical study of portfolio assessment provides ample opportunity for students to participate in showing what they have learned and studied during the learning process (Ozmen and Unal, 2018). This shows that in essence, the portfolio assessment technique is accompanied by a written test, although it is not carried out in a structured manner, when it is implemented in class. The assessment technique given is objective in nature and can provide information about student learning either through observation or by written test. Teachers need to explain that assessment plays an important role in identifying activities that must be carried out by teachers to improve and develop students' abilities through portfolio assessment in written tests.

The results of this study convey that this indicates that students' critical thinking skills in mathematics who receive portfolio assessments are higher than students who receive written tests, portfolio assessments prioritize learning processes that will begin in the form of cognitive, affective and psychomotor aspects, as well as self-assessment structure assignments, notes daily using the grading rubric. Swak et al. (2019) mentioned several advantages of the essay form test. The advantages of the essay test: Encourage test takers to dare to express opinions and provide opportunities for test takers to express their intentions in their own language and way.

Based on data analysis and the results of hypothesis testing, it was concluded that there was a significant influence between the interaction of the problem-based learning model (A) and the type of assessment (B) on mathematical critical thinking skills (Y). In other words, there is a difference in the average students' mathematical critical thinking skills due to the influence of the interaction of the learning model with the type of assessment, after controlling for students' prior knowledge. The results of this study are in line with the opinions of Agbulu and Idu (2018) The Problem Based Learning Model has many benefits such as student-centered learning creating mindsets from different perspectives to make learning more in-depth, active and meaningful and improve skills or abilities to think creatively and think critically student. Based on the results of this study, it is highly recommended for teachers to choose a learning model that is combined with the type of assessment that fits the model. This is done in order to obtain maximum learning outcomes, because if the learning model is combined with inappropriate assessments, the expected learning outcomes may not be achieved properly.

As Noble's statement assesses that through problem-based learning, students can develop their skills in discussing, negotiating, interpreting, grouping, using knowledge in new situations, clarifying, ignoring, reworking, and problem solving. In accordance with the opinion of Hodgman (2019) problem based learning is a learning strategy model in which problem based learning students solve problems and reflect on experiences, develop problem-solving thinking skills.

Supported by the application of portfolio assessment techniques, the learning process of problem based learning which requires collaboration between group members to solve problems can be well controlled. portfolio appraisal technique is very good. According to one expert, Karamiet al. (2018 revealed that portfolio assessment is an assessment tool that is suitable for early childhood because it can assess children's learning outcomes from time to time. This was also expressed by Muslimi (2020), that portfolio assessment is based on the results of various children's work, teacher notes, and self-evaluation carried out by children. is applied in the problem-based learning model because this assessment provides an opportunity for students to control involvement among fellow students.

The statement above is in line with the results of this study and the results of other studies (Hidi, 2021), namely the following research supports the implementation of Problem Based Learning learning, including: (1) understanding of the concept of the model, students who take part in Problem Based Learning learning are better, and more capable of applying molecular transformations from one dimension to two or three dimensions and vice versa, compared to students control group, (2) Teachers and students are an members of the learning community (learning community) where collaboration is one of the keys to the learning experience, (3) working using the Collaborative Hypothesis Tool (CHT) influences communicative activity which shows that collective learning

outcomes can increase, (4) System Problem Based Learning is seen as a pedagogical method which can stimulate students to discuss problems or information from different points of view, to describe and improve by reconstructing and constructing new knowledge as well as to solve problems.

According to Barton & Collins (in Yamin, 2008: 206), all portfolio materials or evidence can be classified into four types, namely: (1) student work (artifacts), namely student work produced in class, (2) Reproductions, namely the work of students done outside the classroom, (3) Attestations, namely statements and results of observations made by the teacher or other parties about students, (4) Production (production), namely the work of students specially prepared for portfolios.

The results of Munawaroh's research (2020) also reveal the advantages of the portfolio assessment technique, namely: (1) the portfolio assessment technique model is significantly better than the conventional assessment model in increasing the mastery of generic problemsolving abilities. mastery of problemsolving pattern recognition skills (analog). and the ability to use problem solving procedures (relate), both in groups of students who have high and low adversity questions (AQ), and in groups of students who have high and low locus of control (LC), but no significant differences were found in improving mastery the ability to find new problem-solving procedures (novelty), (2) the ATS model besides being able to increase mastery of problem-solving abilities, can also encourage increased problem-based learning collaboration skills among individual students in learning to improve mastery of generic problem-solving abilities.

Mastery of problemsolving pattern recognition skills (analog). and the ability to use problem solving procedures (relate), both in groups of students who have high and low adversity questions (AQ), and in groups of students who have high and low locus of control (LC), but no significant differences were found in improving mastery the ability to find new procedures for solving problems (novelty), (2) the ATS model besides being able to increase the mastery of problem solving skills, can also encourage an increase in the ability to cooperate in problem based learning among individual students in learning.

Simanjuntak et al (2021) describe eleven main steps that need to be considered by the teacher, including: (1) determining the purpose of the portfolio, (2) determining the contents of the portfolio, (3) determining the assessment criteria, (4) determining the assessment format, (5) make observations and assessments, (6) determine collections (collection), (7) select evidence (selection), (8) reflection (reflection), (9) meetings, (10) sources and organization, and (11) relationships (connections). As previously stated, any progress made by a child from time to time can be detected, including being able to analyze or review a collection of children's work and various notes on child development from the teacher for a certain period to determine the level of development of children's abilities based on predetermined competencies/indicators and to obtain a final picture of child development through a portfolio-based assessment.

4. CONCLUSION

Portfolio assessment applies the principles of process and learning outcomes in a balanced way. Portfolio assessment follows every aspect of child development, how the child learns, how the motivation to learn, attitudes, interests, habits, and ultimately how the learning outcomes are obtained by the child. Based on this, portfolio-based assessment provides more opportunities to grow and develop optimally according to their potential and in accordance with the stages of child development. Based on the description above, the PBL learning model provides opportunities for students to increase learning interactions both with peers and with teachers. This learning model is very appropriate if the teacher wants to practice critical thinking skills because students can actively participate, work together and exchange information based on the initial knowledge they already have. Class-based assessment is an integral part of the learning model implemented. This class-based assessment technique includes portfolio and written assessment, therefore it is necessary to conduct further studies so that it can reveal the effect of learning models and assessment techniques on critical thinking skills in mathematics after controlling for students' prior knowledge. The limitation of this study is that it only focuses on the influence of critical thinking skills, so that the attitude and

psychomotor domains cannot be accommodated properly. Future research is expected to be able to conduct research on the influence of the psychomotor domain and attitudes on elementary school students. Research on the effect of portfolio assessment on thematic learning is also needed for elementary schools, this is important because elementary school students still use thematic integrative learning approaches.

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