

PjBL and PjBL-STEM: Which model best enhances students' creative thinking?

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Abstract: In this century, humans are required to be able to adapt to the development of the times and are required to be able to answer and solve all problems that arise. One of the abilities that must be developed to face these challenges, namely the ability in the field of creativity. The research's purpose is (1) to determine the differences in students' creative thinking abilities using the PjBL learning model and the PjBL-STEM learning model on class X environmental change material, (2) to determine students' responses to the PjBL-STEM learning model. This research used a posttest only control group design. The population used is class X1-X10 SMA Al Islam 1 Surakarta for the 2023/2024 academic year, a total of 384 students. The sampling technique used cluster random sampling, class X7 with 38 students as the control class using the project-based learning (PjBL) learning model and class X3 with 40 students as an experimental class using an integrated STEM with project-based learning (PjBL) learning model. Data collection was carried out using documentation, tests regarding creative thinking abilities, and student response questionnaires. The data analysis technique was carried out using a one-way t test. The research instruments are teaching modules, LKPD, creative thinking skills questions, and student response questionnaires. The instrument validation technique is carried out using validity tests and reliability tests. The results of the research show that (1) there is a significant difference in students' creative thinking abilities on environmental change material using the PjBL-STEM learning model, (2) students' responses to the PjBL-STEM learning model are included in the positive category.

Keywords: creative thinking skills; environmental change; project-based learning; STEM

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Introduction

Currently we are in the 21st century where in this century humans are being demanded to be able to adapt to the times and be required to be able answer and solve all problems that arise (Zahirah & Sulistina, 2023). Addressing this requires efforts from all levels community, one of which is students. Therefore, the learning process in schools are innovated to enable students to master knowledge and various skills. One of the skills that must be possessed in this century, namely skills in the field of creativity. One part of creativity that cannot be separated is regarding creative thinking abilities. Creative thinking is an ability that a person has in creating ideas or thoughts to overcome a problem and produces something new that no one has ever done before others previously (Anditiasari et al., 2021). According to Faturohman and Afriansyah (2020), creative thinking ability is categorized as one of the abilities high order thinking or also known as High-Order Thinking (HOT).

Rasnawati et al. (2019) stated that creativity in thinking is a must for a person to be an essential basis for use responding to challenges and finding solutions to the problems faced because the problems that arise often cannot be resolved using methods that has existed before, but requires a new approach that can in the form of attitudes, ideas or innovative thought products to achieve solution. There are four indicators of students' creative thinking abilities, namely fluency, flexibility, originality, and elaboration. According to Arini (2017), Creative thinking ability is classified into five criteria, namely not creative, less creative, quite creative, creative and very creative.

Herdiawan et al. (2019) states that the ability to think creatively students in Indonesia are still relatively low so efforts are needed to improve it. This low ability to think creatively is caused by teachers not yet

using a learning model that can emphasize the process thinking skills, especially creative thinking. Most teachers still do using a traditional learning model that is teacher centered. In this kind of learning, students only get information from the teacher resulting in students being less active (Reynawati & Purnomo, 2018). Kahar and Ili (2022) stated that learning activities are a series of activities students do while studying. However, student learning activities often decreased because it was influenced by many factors such as model use inappropriate learning.

One effort that can be made to improve capabilities creative thinking, namely by involving students in learning activities that require students to be able to explore real experiences and develop their own designs to solve problems real life (Sukmawijaya et al., 2019). Learning in the current era has given a reference in choosing a learning model that is adapted to the situation and conditions in the classroom (Afriana et al., 2016). One of the learning models can influence creative thinking abilities, namely learning models Project Based Learning or PjBL integrated with STEM.

Environmental change materials were used in this study because the environmental change is a local issue that is directly related to human life and contains natural phenomena that occur around the environment human life. With this material, students can use their thinking skills to analyze the problems that occur in his environment and then provide solutions to these problems (Sigit et al., 2019). Environmental change concept including the causes of environmental change, environmental pollution, and types of waste can be used to develop thinking skills creative students, such as the ability to come up with unique ideas or solutions and original.

The PjBL learning model is a focused learning model on creative thinking, problem solving, and relationships between students produce and utilize new knowledge (Mawarni & Abdullah Sani, 2020). The application of the PjBL model makes the learning experience more meaningful, so students are more likely to remember what they learn. Model PjBL learning can build students' knowledge and skills solving problems through providing projects as the main focus learning.

According to Anindayati and Wahyudi (2020), STEM is a effective learning approach to improve thinking skills creative. STEM is an example of science in an interdisciplinary field that consists of from four disciplines, namely Science, Technology, Engineering, and Mathematics. The STEM approach aims to enable students to collaborate on the four disciplines this knowledge so that it is able to create new findings (Rukamana et al., 2020). Implementation of a STEM approach is oriented towards solving relevant problems with everyday life. Through the application of a STEM approach in the process learning, students gain a very useful learning experience because they can integrate knowledge, concepts and skills systematically (Dewi et al., 2023).

PjBL integration with STEM approaches provides freedom to students to explore, design, and create their projects so as to trigger students' imagination and encourage their ability to creative thinking. In addition, the collaboration of the two is very possible to present significant learning that can train students in solve problems through the creation of projects that are integrated with one or several other disciplines, such as science, technology, engineering, and mathematics (Wijayanto et al., 2020). One of the characteristics of STEM is the application of EDP or engineering design process (Al Fatihah et al., 2022). EDP in STEM Assist students in designing an appropriate solution to solve the a problem systematically, orderly, and openly through the approach of Jolly (2016). The application of EDP in learning activities in PjBL-STEM classes can create an environment group learning that is able to support students to develop imagination and improve their creative thinking skills in designing creative and innovative products (Mathiphatikul et al., 2019).

The PjBL learning model is integrated with a STEM approach is a form of learning innovation that can improve abilities students' creative thinking (Ulfa et al., 2019). This activity can give students direct experience related to active, fun, and learning meaningful (Riyanti, 2020). According to Pangestika et al. (2020), learning model PjBL-STEM can have a significant effect on creative thinking abilities because it is able to encourage students to be clever in creating and designing, engaging students in learning activities and productivity, emphasizing application of scientific knowledge and problem solving, as well as providing ample space for exploration and collaboration. According to Anindayati and Wahyudi (2020), in use of the PjBL model that integrates STEM students are taught to develop learning that focuses on life problems daily so that students can use the knowledge gained in school and apply it in real world situations. Therefore, model STEM integrated PjBL learning has great potential to build skills relevant to 21st century needs.

Based on the results of observations and interviews conducted by the author with Biology teacher at SMA Al Islam 1 Surakarta, information was obtained that there was the problem regarding the number of students who have the ability to think creatively still low, namely around 65% of students. This is proven by the lack of students' enthusiasm in answering questions when learning takes place and the answers given by students are less varied. Apart from that, when given the task to When making a presentation, students have difficulty finding ways to solve the case given, designing work to fulfil the assignment, and making presentations to explain his discovery. Teachers need to provide stimulus first to encourage the emergence of student creativity. However, the reality on the ground shows that the learning activities carried out are more dominated with the lecture method.

Environmental change material is used in this research because it is material Environmental changes are directly related to human life and contain natural phenomena that occur in the human environment. With material In this case, students can use their creative thinking skills to analyze problems that occur in the environment and then provide solutions to them these problems (Santika et al., 2016). Environmental change material can teach with a more meaningful learning process through involvement students, making it easier for students to understand the material and improve creative thinking ability. Based on the background of the problem, the use of the model PjBL-STEM learning is expected to be an alternative for improve students' creative thinking abilities. So, this research needs to be conducted.

Method

This research is a type of quasi-experiment research with design posttest only control group. In quasi-experiment research, researchers do not have full control over relevant variables. In this context, researchers do not can organize subjects freely based on possible factors influenced the research results because the subjects had been grouped into classes at school (Sugiyono, 2019). A posttest only control group design was used with 2 class groups selected randomly. Both groups were given a posttest after giving treatment. The treatment involves the application of models PjBL learning without STEM integration as a control group, while for the experimental group used the PjBL-STEM learning model. The layout of the research plan can be found in Table 1.

Table 1. Research Design

Class	Treatment	Posttest
PjBL (control)	X1	Q1
PjBL-STEM (experiment)	X2	Q2

Information:

X1: Implementation of PjBL learning model without STEM

X2: Implementation of PjBL-STEM learning model

Q1: Implementation of posttest creative thinking abilities in control class

Q2: Implementation of posttest creative thinking abilities in experiment class

The study was conducted in March until April 2024 at SMA Al Islam 1 Surakarta. SMA Al Islam 1 Surakarta was selected because after observation and interviews with teachers at this school, it was found that as many as 65% of class X students in this school still have low creative thinking skills. The study was conducted in class X in the even semester of 2023/2024.

The population of this study was all students of class X of Al Islam High School 1 Surakarta for the 2023/2024 school year with a total of 384 students. The study sample was a small fraction of the population considered to be can be representative of the entire population in a study. It is important that these samples have characteristics similar to those of the population in the sum. In this study, two classes of samples were used. The selected class is class X3 as an experimental class and X7 as a class control. The details of overall respondents are showed in the Table 2.

Table 2. Sample Class

Class Sample	Treatment	Number of Students
X7	PjBL (Control)	38
X3	PjBL-STEM (Experimental)	40

The sampling carried out in this research was using cluster random sampling technique, namely a technique for taking sample members based on groups. Sample selection was carried out by doing normality test and homogeneity test. The normality test was carried out using ASAS scores for Biology subjects odd semester of the 2023/2024 academic year to find out the data used normally distributed or not. Next, a homogeneity test was carried out for find out whether the data used is homogeneous or not. If conditions normality and homogeneity have been fulfilled, then two classes are randomly selected to be used as a sample in research.

Based on the normality test results of each class. All classes in the population show a significance value of >0.05 , which means class is normally distributed. Thus, the entire class can be used for the next test is the homogeneity test. Then the homogeneity test results show the value significance >0.05 so it can be concluded that each class is homogeneous. Thus, the results of the normality test and homogeneity test of class X1-X10 are normally distributed and homogeneous. Normally distributed classes and are homogeneous and can be selected at random or at random to be used as a sample study. In this study, 2 classes were used as samples, namely class X3 as the experimental class and class X7 as the control class.

The data were collected by using written tests, student response questionnaire, and documentations.

Test techniques used in this research is a posttest. Posttest is carried out after students are given treatment, The goal is to find out the creative thinking ability of students with using the PjBL and PjBL-STEM models. The test given is in the form of Essay totals 10 questions. The form of essay questions was chosen because this type of test can see how the actual ability of students is through the answer that given by students (Syahbana, 2020). The questions are arranged based on the four creative thinking indicators that include fluency, flexibility, originality, and elaboration. While the student response questionnaire is a series of questions or statements that given to several people with the aim of finding information about something using the Likert scale (Sugiyono, 2019). In this study, a questionnaire of student responses was given in an experimental class that received treatment in the form of the application of the PjBL-STEM learning model. Questionnaire student responses consist of 8 numbers with 4 positive statements each and 4 negative statements referring to indicators of creative thinking ability. Documentation techniques are a way of collecting data using the aim is to strengthen the data obtained in the research. Documentation can be in the form of photographs during the conduct of the research.

The validity of this research uses validity and reliability tests. Validity testing is a testing process to assess the extent a measurement instrument can measure accurately what actually desired or measured (Sugiyono, 2019). The validity of the questions was measured using the Pearson correlation validity test technique product moment. Based on the validity test, it shows that all item is declared valid. Reliability testing or level of consistency is related to the ability of the questions this gives the same results even though it is tested over a period of time different times. To find out what questions will be tested has a high level of constancy or reliability, analysis is carried out on answers to the test results using the Cronbach's Alpha Formula (Table 3). Based on the reliability test, the Cronbach's alpha value is known for the instrument about creative thinking abilities is at 0.716, which means the question instrument is valid and has high reliability. Then for the student response questionnaire, the Cronbach's alpha value was 0.691

This means that the questionnaire instrument is also valid and has high reliability.

Table 3. Reliability Criteria

Reliability Index	Criterion Interpretation
0.80-1.00	Very High
0.60-0.80	High
0.40-0.60	Medium
0.20-0.40	Low
<0.20	Very Low

Hypothesis testing is a method used to analyze data statistically with the aim of knowing the significance of the variable to the treatment that has been carried out. Hypothesis testing carried out using a one tailed t test. This test aims to find out differences in students' creative thinking abilities using PjBL learning model and STEM integrated PjBL learning model. Before testing the hypothesis, the data must first be tested for normality and homogeneity. The normality test is used to determine whether the sample data comes from data that is normally distributed or not. To do a test normality can use the Kolmogorov Smirnov test in the software SPSS. The Kolmogorov Smirnov normality test was chosen because of the amount of data greater than 30. The homogeneity test is used to determine whether the two data whether they are homogeneous or not by comparing the two the variance. The conditions for equality of variance testing to be carried out are: if both data are normally distributed. Homogeneity test can be done carried out using SPSS software with Levene's Test.

Results and Discussion

Based on the research that has been carried out, data is obtained in the form of posttest results of creative thinking abilities and student response data PjBL-STEM learning model. Data on creative thinking abilities obtained from two classes, namely class X3 as an experimental class and class X7 as the control class. Meanwhile, student response data was only obtained from experimental class. The experimental class in this study used a model PjBL-STEM learning and the control class use the PjBL model. Data on creative thinking abilities was obtained using posttest questions with environmental change material. The questions consist of 10 items in the form of questions descriptions that have been adjusted to indicators of creative thinking abilities. The calculation of data distribution for creative thinking abilities is presented in Table 4.

Table 4. Distribution of Student Posttest Scores

Class	Control Class Frequency (PjBL)	Experimental Class Frequency (PjBL-STEM)
<i>N</i>	38	40
<i>Mean</i>	74.21	82
<i>Median</i>	75	81.25
<i>Std Deviation</i>	7.92	5.97
<i>Variance</i>	61.21	34.75
<i>Minimum</i>	60	70
<i>Maximum</i>	92.5	95

Based on Table 4, it can be seen that the average value of the control class amounted to 74.21 and the average value of the experimental class was 82. This data shows that the average value of the experimental class is greater than the value control class average. Then the higher the standard deviation value, the more shows a wider range of variation in data for a class.

Figure 1 shows differences in students' creative thinking abilities using the PjBL learning model and the PjBL-STEM learning model. This can be seen from the average score of students given the model PjBL-STEM learning is greater than the average student score given PjBL learning model only. In the experimental class that uses the PjBL-STEM learning model obtained an average score of 82. Meanwhile, the control class uses the PjBL learning model obtained an average score of 74.21. Average value of the experimental class included in the very creative category, while for the control class included in the creative category.

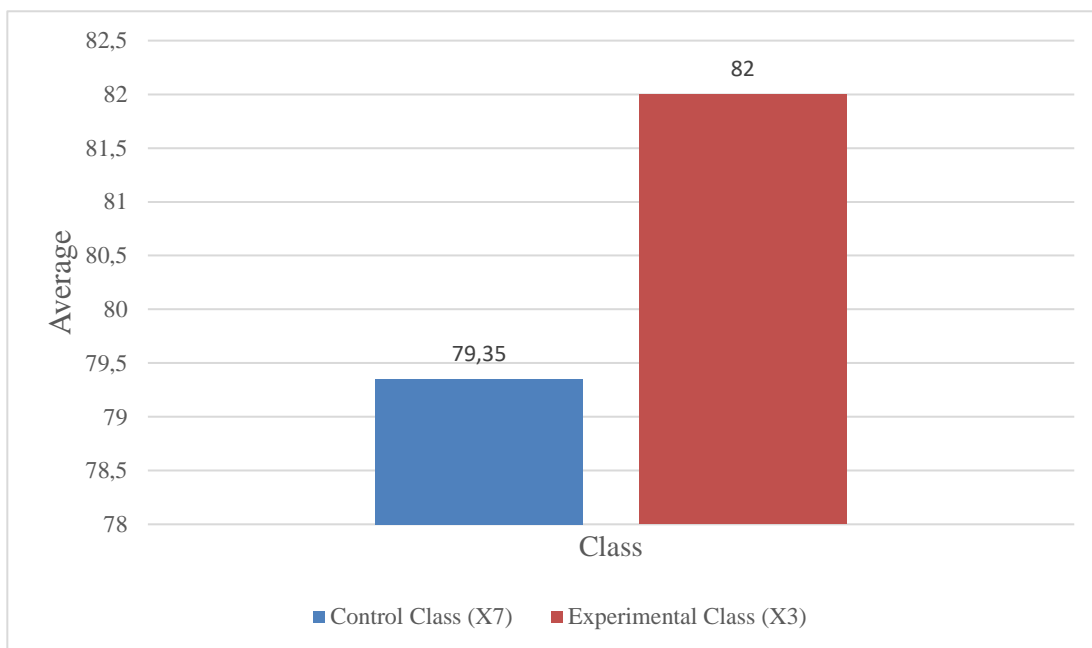


Figure 1. Average of Posttest Creative Thinking Abilities in the control class (PjBL) and experimental class (PjBL-STEM)

Figure 2 shows the differences in scores obtained for each indicator of creative thinking in the control and experimental classes. The figure shows the average value for each indicator creative thinking ability in the experimental class was greater than the average score in the control class. The highest average score was in the experimental class the flexibility indicator is 91.45, while the lowest average value is the elaboration indicator, namely 70.62. Then the highest average value in the control class is found in the indicator flexibility is 82.45, while the lowest average value is found the elaboration indicator is 59.53. This average value shows that the stages or syntax in STEM integrated Project Based Learning are able to improve students' creative thinking abilities.

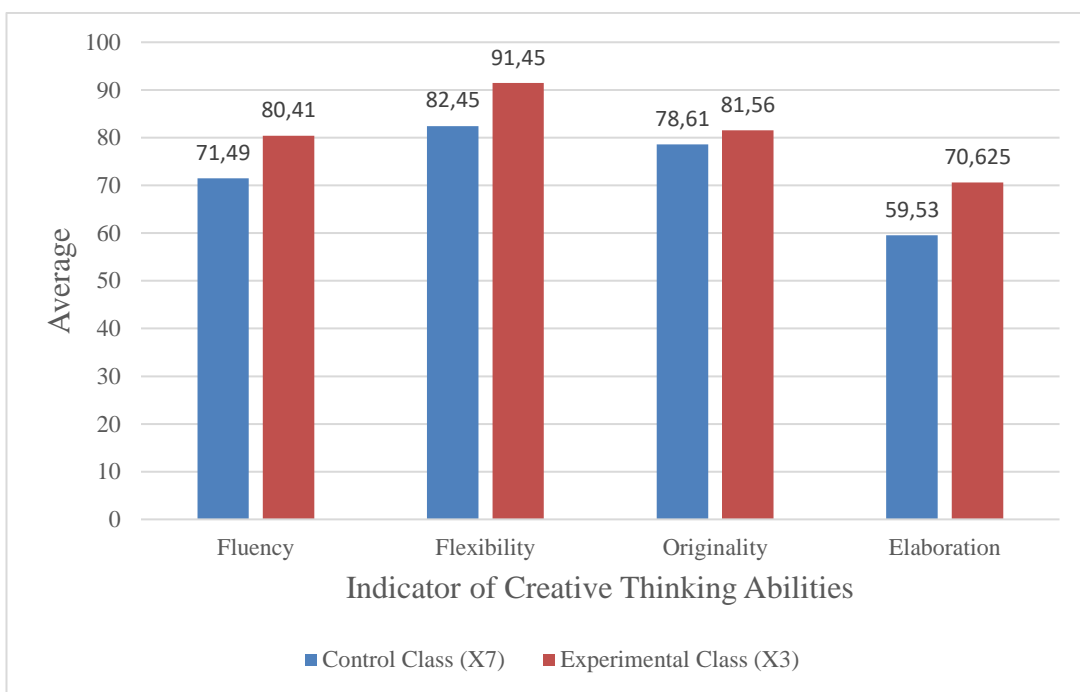


Figure 2. Average of each indicator of student's creative thinking abilities in the control class (PjBL) and experimental class (PjBL-STEM)

In this research, hypothesis testing was carried out using statistical tests with the SPSS 25 application, namely the independent t test. Previous data first tested for normality and homogeneity test as a condition to continue with independent t test. Hypothetical decisions are taken based on levels significance 0.05. If the significance value is <0.05 then H_0 is rejected so it is stated that there is a difference in the average between the sample groups, whereas if significance value >0.05 then H_0 is accepted so it is declared non-existent mean differences between sample groups. The aim of this research is to find out whether there are differences creative thinking abilities of students who use learning models PjBL-STEM and those that use the PjBL learning model. In order to determine this, a hypothesis test is carried out using the t test independent. The results of the independent t test of students' creative thinking abilities will be presented in [Table 5](#).

Table 5. Independent Sample T Test

Indicators	Sig-(2-tailed)	Description	Decision
Creative Thinking	0.000	Sig <0.005	H_0 rejected, there is a difference

Based on the results of the t test, data on creative thinking abilities in [Table 5](#) shows that the Sig.-(2-tailed) value is 0.000. Significance of results This shows that the decision making H_0 is rejected and H_1 is accepted. Matter This shows that there are significant differences regarding creative thinking abilities of students who use learning models PjBL with the PjBL-STEM learning model on change material environment.

Student response data was obtained from the results of a questionnaire given to the class experiment after students receive treatment in the form of applying the model PjBL-STEM learning. The student response questionnaire given consists of 8 statements with a Likert scale of 1-4. Calculation of the percentage of response data students for each statement are presented in [Table 6](#).

[Table 6](#) shows the percentage of student response results to the model PjBL-STEM learning for creative thinking abilities. Results the average percentage for each statement obtained a score of more than 70%. This percentage shows the student's response to the model PjBL-STEM learning is in the positive category. The calculation results the total average percentage of all statements obtained was 79.69% which means the student's response is in the positive category.

Table 6. Percentage of student response questionnaires for each statement

Statement	Percentage of Student Response Questionnaires (%)	Criteria
1	82.5	Positive
2	78.13	Positive
3	80	Positive
4	80	Positive
5	83.75	Positive
6	76.88	Positive
7	79.37	Positive
8	76.88	Positive
Average	79.69	Positive

Based on the data of this study is in line with the research that has been conducted previously by [Mamahit et al. \(2020\)](#) to know the effectiveness of the STEM integrated PjBL learning model on the creative thinking ability. The results of the study show that the model effective in improving students' creative thinking skills. It is because the STEM-integrated PjBL model allows students to actively participate in groups, ask questions, discuss face-to-face problem, express the idea, and design the product together. PjBL-STEM learning can also facilitate the development of students' creativity because in the context of this learning, students are required to create products that stimulate their creativity, especially in solving a problem ([Karlina et al., 2023](#)).

Stages in integrating STEM with the PjBL learning model can improve students' creative thinking skills. The stages are reflection, research, discovery, application, and communication. The reflection stage can help train students' creative thinking skills on fluency indicators. [Putri and Taquudin \(2021\)](#) who stated that the reflection stage is a stage where students will connect the knowledge, they already have previously with the learning materials to be studied. The research stage can train on indicators fluency and flexibility. [Muyassaroh et al. \(2022\)](#) stated that the research stage is the stage where students conduct research or search information related to the solution to be used from various sources. The discovery stage can practicing on originality indicators. [Aeni et al. \(2023\)](#) mentioned that at this stage students discuss the information that has been found to develop the product design they will make. The application stage can train on flexibility and elaboration indicators. According to [Anindayati and Wahyudi \(2020\)](#), this stage aims to testing the product in solving problems and when the product is not yet compliant with the provision that students are asked to make improvements. The communication stage can be training on fluency and elaboration indicators. [Setari et al. \(2024\)](#) stated that at this stage students are able to present the products that have been made and receive constructive feedback provided by other groups.

Conclusion

Based on the research that has been carried out, the results show that there are differences in the creative thinking abilities of students in classes given the PjBL learning model and students given the PjBL-STEM learning model. This difference can be seen from the average score obtained from the posttest results carried out. The control class in this study applied the PjBL learning model and obtained an average posttest score of 74,21 which was included in the positive category. while the experimental class that implemented the PjBL-STEM learning model obtained an average score of 82, this score is included in the very creative category. Apart from that, the results of this research also show that the responses given by students to the PjBL-STEM learning model are included in the positive category with an average percentage of 79.69%. This means that the PjBL-STEM learning model applied to students' environmental change material can have a good effect on students' creative thinking abilities.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author Contributions

A. D. Karina: analysis of data and writing-original draft preparation; **D. Oetomo:** review and validation; **M.Indrowati:** methodology and review; **A. D. Karina, D. Oetomo, and M. Indrowati:** review and editing.

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