



Implementation of *Project-Based Learning Model* Based on STEM *Design Thinking* and Its Effecton toward Critical Thinking Skills of Elementary School Students

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Abstract: Critical thinking skills are essential in assisting students in the learning process, especially in today's 21st century. STEM design thinking based project-based learning is a learning model that can improve critical thinking skills. The purpose of this study is to determine whether there is an influence of the STEM design thinking-based project-based learning model on the critical thinking skills of grade V elementary school students. This study used to a quasi-experimental research approach with a posttest only design. The subjects in this study were grade 5th students of SDN Sentul 03, Babakan Madang district, Bogor, West Java, consisting of 91 students. The way to collect data used is observation, question and answer and recording, with research measuring tools in the form of tests. The hypothesis test used is a t-test to test the level of significance of the influence of the independent variable on the dependent variable. Based on the results of the analysis, it can be seen that the results of the independent sample t-test obtained significance results of $0.000 < 0.05$. The data shows that there is an influence of the use of project-based learning models based on STEM design thinking on the critical thinking skills of grade 5th students of SDN Sentul 03.

INTRODUCTION

Along with the rapid development of science and technology in the 21st century, it requires everyone to have

certain abilities to be able to face the 21st century (Yektyastuti et al., 2019). Facing this 21st century, Indonesia must



prepare the next generation (students) who are suitable to face challenges. The skills that must be prepared in facing the 21st century are *critical things and problems, communication, creativity, and collaboration*. These competencies or skills are known as 4C competencies (Riti et al., 2021). The ability to think critically is the ability to express opinions in an organized way. The purpose of this critical thinking is to achieve a deep understanding (Adri et al., 2020).

Critical thinking can be interpreted as an intellectual ability that enables a person to recognize, evaluate, analyze, formulate the right argument, and make the right decision on the situation at hand (Riti et al., 2021). Thinking logically means that students can understand, formulate problem justifications, theoretical bases, problem solutions, and how to relate them in everyday life. In addition to logical thinking, students also need to be able to think fundamentally critically, which is an active process in which students consider things in detail, ask questions, find relevant information for themselves rather than accepting things from others. With the ability to think critically,

students will be able to solve the problems they face carefully. Thus, the results achieved will be better than things that are not critically thought about (Arsanti et al., 2021).

Critical thinking skills are essential in assisting students in the learning process. This makes critical thinking skills one of Indonesia's main goals. In addition, one of the goals of education is that students have critical thinking skills. Therefore, students are required to have critical thinking skills. This critical thinking skill will enable students to understand the subject matter they receive (Riti et al., 2021). Critical thinking skills can be developed through science learning. In elementary school in the science learning process, teachers teach students to acquire their own knowledge by collecting data through experiments or experiments, making observations to foster curiosity and training students to develop critical thinking skills, so that students are able to solve problems faced by completing projects given by the teacher. This has resulted in critical thinking skills being needed in science subjects in elementary schools (Liwa Ilhamdi et al., 2020).

Critical thinking skills must certainly be conditioned in learning. Empirical facts show that the thinking ability of Indonesian students is consistently still at the bottom. This is supported by research conducted by (Mahanal et al., 2016), and also research conducted by (Hairida, 2016), low intelligence levels in Indonesian students are also seen in research conducted by the *Program for International Student Assessment* (PISA). The results of a study conducted to carve out scientific literacy related to higher-order thinking skills showed that Indonesia was ranked 64 out of 65 countries in 2012, ranked 69 out of 75 in 2015, ranked 62 out of 70 countries in 2018 (Ismawati et al., 2023). In addition, research conducted by Nurul Hayati and Deni Setiawan, the results of critical thinking skills research showed that 12 out of 16 students obtained a percentage of < 50% in the relatively low category. Weak critical thinking skills of grade V students in Natural Sciences learning, due to weak language skills of students and poor reasoning of students (Hayati & Setiawan, 2022). This is also one of the impacts of learning during the Covid-19 Pandemic. The

results of the study show that the Covid-19 pandemic has resulted in learning loss among elementary school students and decreased student learning outcomes (Helmia Tasti Adri, Suwarjono, M Ichsan, 2020; Yektyastuti et al., 2023).

The *approach* is our benchmark for the learning process. The learning strategy used depends on the particular approach. This approach refers to the view of the occurrence of a process that is still very general, in which it accommodates, inspires, strengthens, and underlies learning methods with a certain theoretical scope. STEM is an approach that links and integrates several STEM subjects to create learning based on everyday life problems. STEM aims to develop thinking, reasoning, teamwork, inquiry and creative skills that can be used by students in all areas of student life (Erlinawati et al., 2019).

Thus, learning with a STEM approach can train students to apply the Knowledge learned in school with phenomena that occur in the real world. As it is known that STEM subjects consist of Science, Technology, Engineering and Mathematics. When teachers consider integrating STEM

content, engineering design can be positioned into a framework in learning (Meishanti, 2020).

Project-based learning can be defined as learning where students are given complex tasks that usually contain questions or problems, then students are given the opportunity to work individually or in groups in designing, searching and analyzing and making decisions (Riti et al., 2021). *Project-based learning* is a learning pattern that involves students in an activity, which results in a product. Student involvement begins with planning, designing and communicating the results of activities in the form of products and performance reports (Meishanti, 2020).

Project-based learning is a model that aims to train students in critical, creative and rational thinking, actively collaborating and communicating, and real to students. This model produces a project, in making a project students will make a product, where in making a product can give freedom to students who will be presented to their classmates. The *project-based learning* model can help students in practicing critical and creative thinking

skills to make quality products (Elisabet et al., 2019).

The *STEM-based project-based learning* model is a learning model that shapes students in a group to complete a project, where the project combines science, technology, engineering, and mathematics. *STEM-based project-based learning* has different steps from the *project-based learning* model. The characteristics of the *project-based learning* model with *STEM-based project-based learning* have similarities, it's just that the *STEM-based learning project-based learning* model emphasizes more on the design process or until the process of making *prototypes* (Erlinawati et al., 2019). In addition to the appropriate learning process to be able to improve critical thinking skills, innovations must be made in order to produce approaches and learning models that can maximize students' critical thinking skills. Langkah that can be used in applying and utilizing *design thinking* methods in *project-based learning* models.

Design thinking is a methodology that provides a solution-based approach to solving a problem. The *design thinking* method can certainly

complement the learning process to be more effective, so that students can think critically and creatively (Riti et al., 2021). There are five stages in the *design thinking* process, in the first *is empathy*, in this process it is how to interact with the environment to understand what is needed. The second stage is *define*, in this process is how to determine the problem by focusing on specific *users* based on user needs. The third stage is *ideation*, in this process it is more about doing analysis, so as to bring up ideas. The fourth stage is the *prototype*, in this process it is more about how to apply the ideas that have been collected into physical form, in the form of notes or *storyboards*. The last stage is *test*, in this process is an opportunity to improve existing solutions and make them even better (Dwi T & Sukoco, 2022).

STEM and *design thinking* are expected to improve the skills of students. If combined, it is expected to maximize the improvement of critical thinking skills.

Based on the results of initial observations, the learning that has been done so far does not make students think critically, because learning is still fixated on the teacher. Learning activities are

still carried out by the lecture method. Learning with such an approach makes students less critical thinking in thinking about learning activities so that only the teacher is the source of learning.

The science learning conditions carried out so far at SDN Sentul 03 are based on the results of discussions with grade V teachers of SDN Sentul 03. The teacher said that learning in the classroom still rests on the teacher. In addition, there are some problems found. Of the 49 students, approximately only 10 students are classified as having critical thinking skills. Many students lack focus in the learning process, students when asked are difficult to answer, there are even some students who play with their deskmates when the learning process takes place, students' critical thinking skills are still poorly developed due to lack of understanding received in learning poses.

To overcome these problems, of course, variations of learning models are needed. Teachers need to carry out the learning process using innovative learning mode, so as to facilitate students to be able to have critical thinking skills. A model that can address students

in this context is the *Project-Based Learning* model based on *STEM Design Thinking*.

METHOD

This research uses *quasi-experimental research* or *quasi-experimental* methods. The research design used was *posttest only control group design*. In this design, the experimental class and the control class are randomly selected. The experimental class and the control class are compared, where the experimental class is subjected to treatment while the control class is not. This research was conducted in grade V SDN Sentul 03 Sentul Village, Babakan Madang District, Bogor Regency. In this study, the study used a random sample. Then the population is all grade V students of SDN Sentul 03, which is 91 students, with details of 42 class V A students and 49 class V B students.

In this study, researchers will hold a *posttest* at the end of the study which aims to measure and find out students' critical thinking skills. Trials are instruments used to measure something in certain situations, with techniques and following established regulations. This trial was applied to the

control group and the experimental group with the intention to see the difference in critical thinking skills achieved by students. The requirements that must be met in research instruments are validity tests and reliability tests.

The techniques used in analyzing data use normality, homogeneity, and hypothesis tests. Data normality assessment is carried out with the aim of obtaining information about the normal distribution. The *Kolmogorov-Smirnov* test was used in this study with a significance of 5% or 0.05. The declared data is normally distributed if the value of Sig. (2-tailed) > 5% or 0.05 (sig > 0.05).

After conducting a normality test and deciding that both classes of samples are declared normally distributed, a homogeneity test is carried out. The test is used to determine whether the experimental class and the control class have uniform variations or not. In this study, *Levene Statistics* was used for homogeneity testing with a significance level of 5% or 0.05.

If it is normally distributed, then the next step in testing the research hypothesis is to use *an independent sample t-test*. The test is used to show whether there is a significant difference between critical thinking skills using the *STEM-based design thinking project-based learning model* and the *project-based learning model*.

Ha: there is an influence of the use of *project-based learning models based on STEM design thinking* on students' critical thinking skills.

Ho: there is no use of *project-based learning models based on STEM design thinking* on students' critical thinking skills.

By decision criterion: If the value of Sig. (2-tailed) < 0.05 then Ho is rejected. If the value of Sig. (2-tailed) ≥ 0.05 then Ho is accepted.

RESULT & DICUSSION

Result

This research is an experimental research with *quasi-experimental research*, with a type of *posttest-only control design*. This study aims to determine whether there is an influence of the *project-based learning model based on STEM design thinking* on the critical thinking skills of grade V

students with water cycle material at SDN Sentul 03 Bogor Regency, then research data analysis was carried out. This research will be conducted from February 22, 2023, to April 5, 2023.

Researchers obtained data using test techniques after learning with different models between experimental classes and control classes. At the time of learning, students in the control class use a project-based learning model, while students in the experimental class are given treatment using a *project-based learning model based on STEM design thinking*.

Before the instrument was given to the control class and experimental class as a measure of students' critical thinking skills, it was first tested in class V SDN Puspanegara 01 which had received water cycle material. Trials are carried out to measure whether the question is feasible or not, if it is feasible then the instrument is suitable for use. As for the results of the trial questions, they are as follows:

Research data validation is a series of actions that ensure consistency in a research variable that links the research process with various data reported by researchers (Sugiyono, 2019). The

validation test aims to determine whether the question item is valid or not. If a question item is considered valid, it can be used in the *posttest*. Based on the test that has been carried out with 32 students and a significant level of 5% in the *table* $r = 0.349$, so the question item is said to be valid if the value of r is *calculated* $> 0,349$ ($r_{count} > 0.349$). Researchers in validating each question use the SPSS 22.0 *software* program. The question criteria are considered valid or not depending on the results of the SPSS *output* seen in *the correlations* compared to a significant level of 5% or 0.05.

After the validity test is carried out, then test the reliability of the instrument. Reliability testing can be carried out simultaneously. If the Alpha value > 0.6 , it is said to be reliable (Sujarweni, 2019). From the results of calculations that have been carried out using the SPSS 22.0 *software* program. Alpha values of $0.731 > 0.6$ were obtained. So it can be said that the question points are reliable. The next stage is the normality and homogeneity test, then proceed with the

hypothesis test Here are the results of the prerequisite test in data analysis:

From the results of calculations that have been carried out using the SPSS 22.0 *software* program, calculating the normality test will produce a sig value. (2-tailed) In the *Kolmogorov - Smirnov* column that shows whether the distribution of data is normal or not. Data requirements that must be met when the data is normally distributed if the significance obtained is greater than 5% (signification > 0.05).

Based on the table of normality test calculation results, it shows that the *posttest* significance value in the experimental class group is 0.200 and the *posttest* significance value in the control class group is 0.067. This shows that both values in the experimental class group and the control class group are greater than 0.05. After carrying out the normality test, a homogeneity test is carried out. The basis for the decision taken in the homogeneity test is that the significance value must be greater than 0.05 so the data is said to be homogeneous. Homogeneity test calculations have been carried out using the SPSS 22.0 *software* program. The results of the normality test for the

distribution of posttest data on students' critical thinking skills can be presented in a table, namely:

Table 1 Hasil Perhitungan Uji Normalitas

Posttest Keterampilan Berpikir Kritis Siswa	Kolmogorov Smirnov	
	df	Sig.
Kelas Eksperimen	49	.200 ^a
Kelas Kontrol	42	.067

The results of data homogeneity test calculations can be presented in a table, namely:

Table 2 Hasil Perhitungan Uji Homogenitas

Levene Statistic	df1	df2	Sig.
.670	1	89	.415

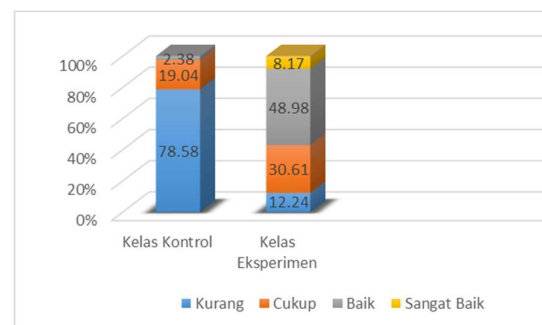
The homogeneity test calculation table shows that the significance value is 0.415, meaning the significance value is $0.415 > 0.05$. So the data is homogeneous.

Next, a hypothesis test is carried out. Posttest data in the experimental class group and control class group serves to determine whether there is an influence on the use of a project-based learning model based on STEM design thinking. Based on the results of the hypothesis test, it is known that the independent sample t-test results

obtained a significance value of $0.000 < 0.05$. This shows that there is an influence of using a project-based learning model based on STEM design thinking on students' critical thinking skills.

Discussion

Based on the results of the posttest data analysis, it can be seen in the picture of the posttest results of critical thinking skills for experimental class and control class students.



Gambar 1 Hasil Posttest Keterampilan Berpikir Kritis

Based on the image data above, it can be seen that in the experimental class which implemented a project-based learning model based on STEM design thinking, the percentage of students in the good category was 48.98%, while in the control class which was taught using the project-based learning model, with the good category only reaching 2.38%. This shows that the project-based learning model based on

STEM design thinking further improves students' critical thinking skills.

The results of this research are in line with research by Gloria I.R.W Atmojo and R. Ardiansyah (Gloria, Atmojo, I. R. W., & Ardiansyah, 2022), showing that project-based learning using the design thinking method is effective for creative thinking. This is proven by the score $p(0.025) < \alpha(0.05)$, proving that the PjBL model with the design thinking method can influence creative thinking skills. The magnitude or level of the resulting impact score is 6.66%. From the results of the significant value, it can be concluded that the working hypothesis (H_a) which reads "There is an influence of Project-Based Learning with the design thinking method on creative thinking skills in science learning" is accepted.

Then research conducted by Ines Dwi Astuti, Toto and Lia Yulisma (Astuti et al., 2019), shows that the STEM-based Project-Based Learning model can increase students' mastery of concepts in Ecosystem material which is included in the (high) category. And the STEM-based Project-Based Learning model can increase student activity in the (very active) category.

The project-based learning model based on STEM design thinking certainly has several advantages and has great potential in empowering students' critical thinking skills. The activities carried out in this learning refer to the project-based learning stages provided that they are also integrated with STEM (Science, Technology, Engineering, and Mathematics) aspects and use a design thinking approach. The results of observations of the implementation of project-based learning based on STEM design thinking that have been carried out are as follows:

The initial stage of learning is the reflection stage, where researchers guide students to find problems. At this stage the initial stimulus is given to students to find problems, through a water cycle demonstration method which is not only carried out by researchers, but students also carry out the process. Students are guided to find the problems of the problems they face. The skills mastered by students are the ability to formulate problems, determine the variables in the problem formulation. Don't forget, students also take a design thinking approach with

empathy and define stages, in this process students interact with their environment to understand what is needed and how to find problems with a specific focus based on the needs of the problem.

The second stage of learning is the research stage, where students are guided to find what solutions to take to solve the problems found from the reflection stage. The method used in this stage is group discussion. To make the discussion more focused, students are assisted with questions in the LKPD (Student Worksheet) that lead to the expected solution. The stage in the design thinking approach is ideation, in this process it is more about carrying out analysis, thereby generating ideas.

The third stage of learning is the application stage, where this stage is carried out using practical methods. Students in groups create a water cycle diorama. From the application stage, students are able to master science process skills related to designing, using tools and materials, and testing practical results. The stage in the design thinking approach is prototype, in this stage it is more about how to apply the ideas that have been collected in physical form.

The final stage of learning is the communication stage, students at this stage report the results of the projects they have carried out and discuss together in class. From the communication stage, students are able to master communication skills both verbally and in writing. The final stage in the design thinking approach is testing, in this process it is an opportunity to improve existing solutions and make them even better.

Learning outcomes using the project-based learning model based on STEM design thinking in this research can be measured through the results of the posttest that has been given, paying attention to critical thinking indicators, namely: 1. Providing a simple explanation (elementary clarification); focusing questions, analyzing question arguments, asking and answering questions. 2. Building basic skills (basic support); whether the source is trustworthy or not, observe and consider the operation results report. 3. Make inferences (inferring); deduce and consider the results of the deduction, induce and consider the results of the induction, determine the considerations. 4. Make further

explanations (advanced clarification); define terms, identify assumptions. 5. Arrange strategies and tactics (strategies and tactics); deciding on an action, interacting with other people (Marudut et al., 2020).

Having critical thinking skills allows a person to be able to organize, adjust, change or improve their thoughts. So students can make decisions and act more quickly. Students will experience a rational process before making a decision. In critical thinking, the rational process aims to make a decision whether to believe in doing something. In summary, it can be said that critical thinking is a dynamic process which allows students to detect differences in information, collect data, analyze data, and evaluate and conclude the information or data obtained. In this complex world, it is very important for students to think critically. In this era, education not only demands students in terms of material assignments but also requires students to have cognitive and social skills in solving existing problems (Adri et al., 2020; Siahaan & Meilani, 2019).

Cognitive abilities that will condition a person to identify, analyze, evaluate, formulate appropriate reasons to draw conclusions in making decisions about something are called critical thinking (Riti et al., 2021). Critical thinking is a thinking process in a direction that further improves the ability to analyze problems, find solutions to problems and produce new ideas that can provide a new picture of problem solving (Ariani, 2022). The posttest results of students' critical thinking skills at SDN Sentul 03 in the control class obtained an average result of 45.76, a minimum score of 22 and a maximum score of 76. Meanwhile in the experimental class the average result was 79.22, a minimum score of 44 and a the maximum is 82. So it can be interpreted that the average value of critical thinking abilities of class V students in the control class is categorized as poor, while the average value of critical thinking abilities of class V students in the control class is categorized as good.

CONCLUSION

The conclusion that can be drawn from the results of the analysis and discussion shows that the project-based

learning model based on STEM design thinking is more influential than the project-based learning model. The application of project-based learning based on STEM design thinking is able to improve students' critical thinking skills in science lessons at SDN Sentul 03. The significance value shows $0.000 < 0.05$, so H_0 is rejected. So there is an influence of using a project-based learning model based on STEM design thinking on students' critical thinking skills.

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