The Effect of the Project Based Learning-STEM Model on Students Critical and Creative Thinking Skills

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Abstract. This study aims to see the effect of the STEM integrated project-based learning model on Optical Instruments material. This type of research is a quasi-experimental (quasi-experimental) because the class used for treatment is the control class and the experimental class. two study groups were used as the research sample which was divided into the experimental class category with the STEM-integrated project-based learning model and the control class with the conventional model. This research was conducted on students of class XI even semester at SMA N 15 Takengon. The results showed that the average value of the experimental class was greater than that of the control class which was known by the Manova test. So it can be concluded that there is a significant influence of the STEM-based project-based learning model on students' critical and creative thinking skills in the material of Optical Instruments.

Keywords: PJBL-STEM, Critical Thinking Skilss, Creativity Thinking Skills

1 Introduction

Education is a very important human need, because education can create quality and characterful human beings who have broad insights so that they can achieve the expected goals. The progress of a nation is determined by education and the advancement of education in the people of that nation. This can be realized by organizing effective, efficient and fun education.

Education plays an important role in preparing a generation that is able to compete in the 21st century accompanied by rapid advances in modern technology. In the 21st century, students need to be formed to be skilled in problem solving, both in making decisions, thinking creatively, having skills in deliberations, communicating ideas effectively, and being able to work efficiently both individually and in teams. Education must be immediately changed or transformed from traditional learning to modern learning [1]. One of the 21st century skills that students need to have is higher order thinking skills (HOTS).

HOTS is a thinking process that requires students to manipulate existing information and ideas by combining facts and ideas in the process of synthesizing, generalizing, explaining, conducting hypotheses and analysis, to the ability to conclude [2]. HOTS is the ability to analyze something based on available data and find many possible answers to a problem with an emphasis on quantity, effectiveness and variety of answers [3]. The main characteristic of HOTS is the ability to think critically and be able to think creatively [4].

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Critical thinking skills are a process that aims to make reasonable decisions about what to believe and what to do [5]. In addition to critical thinking skills, one important aspect of HOTS is creative thinking [6]. Creative thinking is a thinking activity that produces new methods, concepts, definitions, discoveries and works. Critical and creative thinking skills are very important for students to master in order to be able to solve problems faced in a world that is constantly changing [7].

One of the causes of students' low critical thinking skills is the habit of students who are more likely to already feel comfortable with the teacher's explanation without questioning more deeply. The low ability of critical thinking in students is caused by several factors. One of them, when students in a class actually do not carry empty knowledge, but they have knowledge that is fragmented, so that students experience difficulties when associating a concept with one another.

Conventional learning applied by teachers in schools cannot form students' critical and creative thinking skills properly. Based on the description of the problem, it is necessary to make efforts to overcome the problem above. One of them is by applying an effective learning model, which attracts students' attention, generates motivation, involves students actively, and trains students' critical and creative thinking skills to improve the quality of learning processes and outcomes. One alternative that can be used to overcome these difficulties is to create learning activities that aim to guide students in critical and creative thinking. The project based learning (PjBL) learning model integrated with the science, technology, engineering and mathematics (STEM) approach is one of the creative and active learning that can help students develop critical and creative thinking skills.

PjBL is an effective learning model for improving critical thinking skills because in each phase it encourages students to be active in learning, such as in the planning stage students are trained to be able to decide on an action. Learning with the STEM approach can shape the character of students who are able to reason highly and think critically, logically and systematically [8]. STEM-integrated PjBL can increase learning effectiveness, produce meaningful learning, and support future careers [9].

Based on the background above, the formulation of the problem in this study is obtained, namely: 1) Is there a significant influence of the STEM integrated project based learning model on students' critical and creative thinking skills? 2) Is there an increase in students' critical thinking skills taught using the STEM integrated project based learning model? 3) Is there an increase in students' creative thinking skills taught using the STEM integrated project based learning model?

Based on the formulation of the problem, this study aims to 1) determine the significant effect of the STEM integrated project based learning model on students' critical and creative thinking skills 2) determine the improvement of students' critical thinking skills taught using the STEM integrated project based learning model? 3) find out the increase in students' creative thinking skills taught using the STEM integrated project based learning model?

2 Research Method

Quasi-experimental study with a two group pretest-posttest design. When the research was conducted in the even semester of April 2022. Based on the research objectives, the

population in this study was all of SMA N 15 Takengon . The sample in this study consisted of class XI IPA 2 and XI IPA 3 which were taken by simple random sampling technique. In this study, data were obtained by several methods, namely: direct observation, interviews, and documentation. The data analysis technique used in this study is the normality test, homogeneity test, n gain test, manova test and correlation test.

3 Results And Discussion

This research was carried out in class XI semester II SMA N 15 Takengon TA 2021/2022. The population in this study were all students of class XI consisting of 4 classes with a total population of 128 people. This type of research is a quasi experiment involving 2 classes. Class XI MIA 2 consists of 28 students as an experimental class using the PjBL STEM model and class XI MIA 3 as many as 28 students as a control class using a conventional model.

Post-test data hypothesis testing can be done if the post-test data meets the requirements, namely the data is normally distributed and homogeneous. Based on the calculation results, it can be concluded that the post-test data are normally distributed and homogeneous so that the hypothesis testing in this study uses the post-test average similarity test using the Manova test with the help of SPSS 21.0.

Table 1. Results of the Manova Posttest Critical and Creative Thinking Skills

No	Effects	Sig
1	*Piilai's Trace*	0,00
2	*Wilk's Lambda*	0,00
3	*Hotelling's Trace*	0,00
4	*Roy's Largest Root*	0,00

Table 1 aims to see whether there are differences between students who are taught using the conventional model and the PjBL STEM model on students' overall critical and creative thinking skills. Table 3.1 obtained a significance value less than 0.05 so that H 0 was rejected. Based on these data it can be concluded that there are differences in critical and creative thinking skills in the control class and the experimental class.

The results of the Manova test can also be seen the difference in each indicator shown in Table 2.

Table 1. Test Results Between Subject Effects on Posttest Critical and Creative Thinking Skills

No	Effects	Sig
1	Critical Thinking Posttest	0,00
2	Creativity Thinking Posttest	0,00

Table 2 aims to see whether there are differences in students' critical thinking skills taught using the conventional model with the PjBL STEM model. You can see the difference in each skill. Based on Table 3.2, it can be seen that the significance values for critical and creative thinking skills are each smaller than 0.05, which means that H 0 is rejected and Ha is accepted. Based on this, it was concluded that there was an influence of the PjBL STEM model on students' critical and creative thinking skills.

The percentage of students' critical thinking skills improvement can be calculated by the normalized gain test (N-gain). The average pretest and posttest scores in the control class will be analyzed as a whole and also for each indicator. The increase in N-gain of critical thinking skills as a whole was obtained by 0,50 which was included in the medium category. The results of calculating N-gain on critical thinking skills per indicator can be seen in the image below :

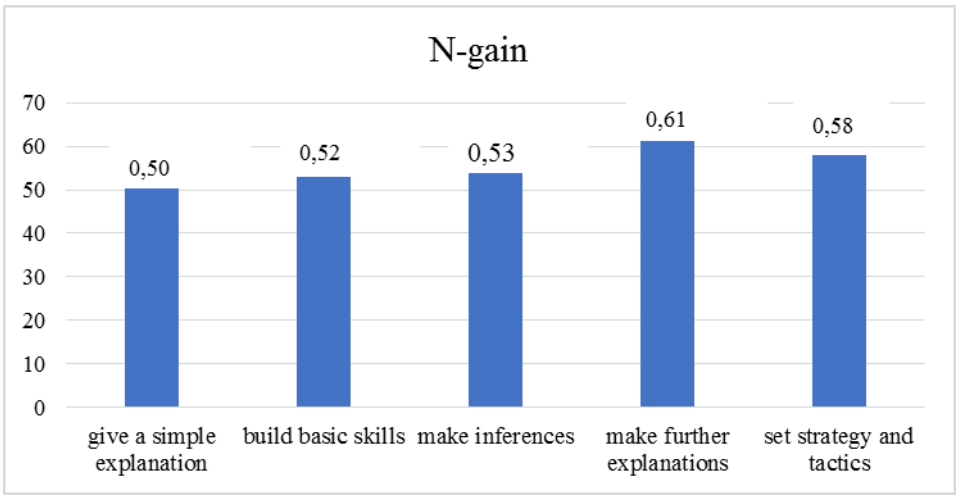

Figure 3 N-Gain Value Per Indicator Critical Thinking Skills Experiment.

Based on Figure 3 it shows that there is an increase in students' critical thinking skills in answering each indicator of the critical thinking skills test in the experimental class. The N-gain value for the critical thinking skills indicator for the experimental class is higher than that for the control class. Based on Figure 3 it shows that there is an increase in each indicator providing a simple explanation of 0,50 in the indicator building basic skills by 0,52 in the indicator making inferences by 0,53 in the indicator making further explanations by 0,61 and on indicators set strategy and tactics by 0,58.

The increase in creative thinking skills for each indicator was also calculated and the average value was obtained from the students' answers for each indicator in the experimental class using the pre-test and post-test values that had been given. The overall increase in N-gain for creative thinking skills was 51.34% which was included in the medium category. The calculation results for each indicator of creative thinking skills are shown in Figure 4.

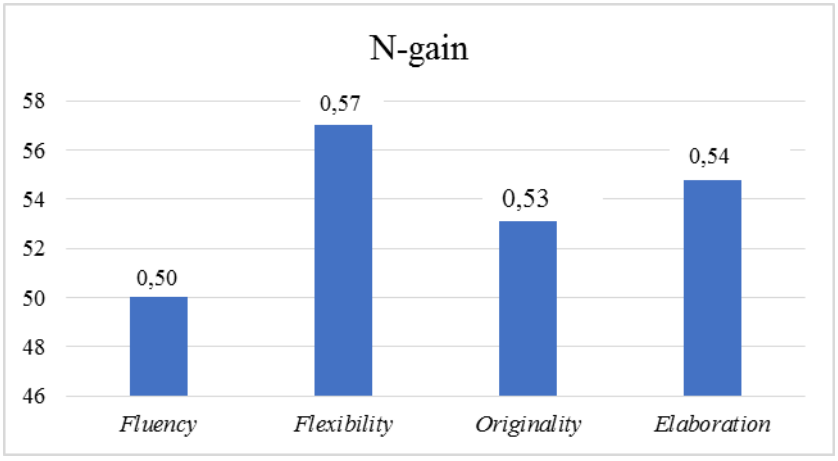

Figure 4 N-Gain Value Per Indicator Creative Thinking Skills Experiment.

Based on Figure 4 it shows that there is an increase in each indicator of creative thinking skills. The N-gain value on the fluency indicator is 0,50, on the Flexibility indicator is 0,57, on the Originality indicator is 0,53 and on the Elaboration indicator is 0,54

Students critical and creative thinking skills taught using the STEM-integrated PjBL model were higher than the control class. Critical thinking skills in the experimental class are seen in the first phase of fundamental questions and the fifth phase of presenting the project. In the first phase the teacher gave problems related to everyday life and students were very enthusiastic in answering them, because in the experimental class using the STEM PjBL model students were given an initial stimulus in the form of a learning video that contained physics concepts which are one aspect of STEM so that students' reasoning when searching solutions related to Optical Instruments material in everyday life are very logical based on evidence and direct observation.

Critical thinking skills are also better in the process of designing a project, the process of designing or designing a project by criticizing and evaluating their own designs on thinking power to solve problems, this can train students' critical thinking skills well. Identification of the right solution in making a design requires careful thinking on the part of students, this exercise requires students to evaluate critically and communicate the various benefits and drawbacks of each design alternative. Critical thinking skills are also encouraged to be better in subsequent meetings.

The next thinking skills are students' creative thinking skills. Creative thinking skills are seen in the second phase (designing the project) and the fourth phase (working on the project). The second phase is designing projects, creative thinking skills are seen when students are designing projects, students are given freedom in designing projects, when designing projects related to Optical Instruments students are very fluent and original in determining what designs to make, students draw patterns and Designing a project on cardboard is one of the aspects of STEM, namely engineering (techniques) to make it easier to make projects, students design schedules to make star telescopes, loops, and periscopes. Creative thinking skills are also seen in the fourth phase, namely working on projects. The indicator of creative thinking

skills that can be seen in the fourth phase is the flexibility indicator , namely when working on student projects both in class and at home, students are able to solve their own problems and create new strategies in making projects. The Optical Devices Project made by students relates to one aspect of STEM, namely technology (technology). PjBL can make students more creative, both in skills and in the attitude they carry out in project work [10].

The improvement of students' critical and creative thinking skills is measured by the N-gain test. The increase in the value of students' critical thinking skills in the experimental class was because students who learned to use the STEM-integrated PjBL model were trained to analyze the right opinions in groups in solving solutions. Designing projects according to student findings from trusted supporting sources can train students' critical thinking skills.

Based on the explanation above, we can see that learning using the STEM-integrated PjBL model can improve students' creative thinking skills. Through project-based learning can lead to dissatisfaction to synthesize a phenomenon that is born through creative thinking [11]. Thinking of choosing the most appropriate solution based on multiple solutions of creative thinking. Through this process can grow critical and creative thinking skills.

4 Conclusion

Based on the results of research on the subject matter of Optical Instruments in class XI SMA N 15 Takengon TA 2021/2022 and the discussion, the following conclusions can be drawn there is a significant influence on the STEM-integrated PjBL model on students' critical and creative thinking skills.The increase in students' critical thinking skills is 0,50 (moderate category). The increase in students' creative thinking skills is 0,51 (moderate category).
Based on research conducted from the preparation, implementation and data processing stages, the researcher has suggestions for further research, namely preparing sufficient resources in preparing worksheets and instruments to be used, explaining learning activities using the STEM-integrated PjBL model clearly and ensuring students understand it, Explaining the STEM process in research is clearer and more detailed in the learning process and on student worksheets.

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