The Effect of Project Based Learning Model on Critical Thinking Skills oh High School Students

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Abstract. The purpose of this research is to determine how the project based learning (PjBL) model affected the critical thinking skills of students enrolled in the optic tools course during the 2022–2023 school year at SMA N 1 Kisaran. A quasi-experimental approach with a pretest-posttest layout was used for this study. Every single student at XI MIA SMA N1 Kisaran makes up the study's population. Cluster random selection was used to choose a sample for this study from two classes: the experimental class(XI MIA 7 and the control class XI MIA 5, which consists of 25 students. The instrument that used is problem based essay test, which are 10 questions had valid. The result of data analysis got from the average pretest class value from experiment class is 50,84 and control class is 51,72, besides that the average of posttest class value is 85,44 and control class is 67,28. The increasing percentage of critical thinking skill based on N-Gain got from experiment class (high category) is 70% and 32% from control class (medium category). The highest N-gain percentages based on indicators of critical thinking skill are strategy and tactic at experiment class (high category) is 80% and 39% at control class (medium category. Conventional learning leads to significantly different results in terms of students' critical thinking abilities; hence, the PjBL model is superior than conventional learning when it comes to improving students' critical thinking abilities.

Keywords: Project Based Learning, Critical Thinking Skill, Optic Tools.

1 Introduction

An educated populace is better equipped to deal with the challenges posed by the exponential growth of technology in the twenty-first century. This generation's youth must be prepared to face the challenges of the modern world with confidence, creativity, resourcefulness, critical thinking, deliberation, effective communication, and teamwork skills. To ensure this, education must undergo a radical shift from its current focus on conventional wisdom to one that emphasizes the use of technology [1].

Competence in the modern world is a prerequisite for success in school. A key competency for the modern day is the ability to think critically [2]. The ability to think critically is a process whose end objective is to help one make sound judgments regarding matters of belief and action [3]. Critical thinking skills that are trained will make students have great curiosity, be current, have trustworthy reasoning, be flexible, be integrity with personal prejudices, be careful in making decisions, be transparent in issues, and be balanced in evaluating [4].

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Physics is a great field to study if you want your kids to become better thinkers. Understanding the cosmos and its interconnections is the goal of physics, a subfield of the IPA. Learning physics may help students develop their critical thinking abilities since the subject teaches them to analyze and understand the world around them in order to draw conclusions and draw conclusions that can be accepted and understood in an objective, honest, and reasonable way.

According to the findings from the study that was carried out on the physics professors at SMA N 1 Kisaran, teachers tend to teach in a conventional teacher-centred way with a mathematical approach, giving example questions and exercises and rarely conducting experiments. Results from a critical analysis questionnaire given to 33 students showed that 27 of them (or 81% of the total) still exhibited a lackluster degree of critical thinking, and 6 students (19%) had a moderate level of critical thinking. Conventional learning applied by teachers in schools cannot form critical thinking skills well. One solution that can equip students with the critical thinking is a project-based learning (PjBL) model.

Project-based learning is an approach to education that emphasizes the creation of presentable, publishable outcomes as the first step in the learning process [5]. Stages in the *project-based learning* paradigm encourage students to think critically as they work on class projects to address teacher-posed difficulties [6].

That students' critical thinking abilities are enhanced via project-based learning is backed by [7]. These are the features of PjBL as described by [8] are: (1) preparing students to investigate (investigations), (2) solving problems, (3) providing meaningful activities, (4) building students' knowledge independently, and (5) creating products that good and realistic.

2 Research Methods

This study was place in the seventh class (even semester of T.P. 2022/2023) at SMA N 1 Kisaran. We used *cluster random sampling* to conduct the sampling. Class XI MIA 7 served as the experimental group, while class XI MIA 5 served as the control group, receiving both traditional and *project-based instruction*. This study utilized a *two-group pretest-posttest design*, which is indicative of a *quasi-experimental* approach (Table 1).

Table 1. Two Group Pretest – Posttest Design

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Class	Pretest	Action	Postest
Experiment	Y	X_1	Y
Control	Y	Y_2	Y

Note:
X_1 = *project based learning* model in class XI optical instrument material
X_2 = conventional learning in class XI optical instrument material
Y = *critical thinking pretest and posttest* given to the experimental class and control class before and after treatment.

This study tool is an evaluation of your analytical and deductive reasoning abilities as they pertain to optical devices. A ten-question essay focused on real-world problems serves as the exam format. Genuine key indications are included in every inquiry.

Prior to doing the t test, it is necessary to ensure that the data from both groups is normal and consistent. The purpose of the normalcy test is to ascertain whether the sample is representative of a normally distributed population. Check for data normality using SPSS 20.0's Shapiro-Wilk test. The purpose of the homogeneity test was to see whether the two classes included in the study sample were statistically similar and thus representative of the population as a whole. Using SPSS 20.0, the homogeneity test was conducted. Using the t test, we examined the preexisting hypothesis.

The percentage increase in critical thinking skills is calculated using the N-Gain formula, namely:[9]

$$^{\%}\, g = \frac{posttest\ value - pretest\ value}{\max value - pretest\ value} \text{ x } 100^{\%}$$

3 Result and Discussion

Result. Table 2 displays the results of a pretest measuring critical thinking abilities that were administered to both groups before to the commencement of the learning process.

Table 2. *Pretest* Data on Critical Thinking Skills in Control and Experiment Classes

Classes	Min Value	Max value	Average
Control	33	68	51,72
Experiment	37	62	50,84

The PjBL model was used to treat the experimental group, whereas the control group received traditional instruction. The sub-material on optical equipment has been covered. The *post-test* questions for critical thinking abilities were provided to both classes; they are similar to the pretest questions in order to measure whether or not students' learning improved after treatment. Table 3 displays the findings of the posttest measuring critical thinking abilities in this research.

Table 3. *Posttest* Data on Critical Thinking Skills in Control and Experiment Classes

Classes	Min value	Max value	Average
Control	60	74	67,28
Experiment	77	91	85,44

The normalcy test was used to ascertain whether the *pre-* and *post test* data for the control and experimental classes followed a normal distribution. We used SPSS 20.0 and the *Shapiro-Wilk* test to check for normality. You can see the results of the normalcy test for the two classes' pre- and post-test data in Table 4.

Table 4. Normality Test using *Pretest* and *Posttest* Data

Information	Expriment		Control	
	Pretes	Postes	Pretes	Postes
Sig	0,590	0,924	0,260	0,342
Conclusion	normal	normal	normal	normal

Normalcy is defined as *sig* > 0.05. Both the pretest and posttest data had *sig* values higher than 0.05, as shown in Table 4. It follows that a normal distribution best describes the data. A test of equivalence of two variances was used to determine if the experimental class and control class's *pre-* and *post-test* data were homogenous. The results showed that the two classes' data were *h*omogeneous, indicating that the data gathered could be applied to the whole population. Table 5 shows the results of the homogeneity test that was conducted using SPSS 16.0.

Table 5. Homogeneity Test using *Pretest* dan *Posttest* Data

	Classes	Sig	Conclusion
Pretest	Control Experiment	0,062	Homogeneous
Posttest	Control Experiment	0,805	Homogeneous

The condition for data to be said to be homogeneous is *sig* > 0.05. As shown in Table 5, the significance levels of both the *pretest* and *posttest* data sets are higher than 0.05, indicating that the data follows a normal distribution.

Once the necessary tests have been completed and it is confirmed that the data follows a normal distribution and is homogenous, the t test is used to test the hypothesis. Table 6 displays the results of the hypothesis test calculations that were conducted using the t test on the *pretest* data from both the experimental class and the control class.

Table 6. Hypothesis *Pretest* Test Critical Thinking Skills

Classes	Average	t_{count}	t_{table}
Control	51,72	0,359	2,010
Experiment	50,84		

According to Table 6, both the experimental and control groups of students started out with identical levels of critical thinking abilities when it came to optical material. Table 7 shows that after administering separate treatments to the two groups, students' ultimate skills varied.

Table 7. Hypothesis *Posttest* Test Critical Thinking Skills

Classes	**Average**	**t_{count}**	**t_{table}**
Control	67,28	17,018	2.010
Experiment	85,44		

According to Table 7, it is found that the average *posttest* score for the experimental class is higher than the control class and $t_{count} > t_{table}$, namely 17.018 > 2.010. These findings suggest that the *project-based learning* model's impact on optical material in class XI, semester II, SMA N 1 Kisaran T.A. 2022/2023, has a noticeable effect on students' critical thinking abilities.

Students' performance on assessments of their critical thinking abilities was compared across the two courses used for the comparison. The N-gain for the control group was 32% and the experimental group was 70% according to the calculations. You can only get a maximum of 10 on questions testing your critical thinking abilities. There are two questions for every sign of critical thinking. Table 8 and Figure 1 show the results of comparing the experimental and control groups' increases in each critical thinking skill indicator.

Table 8. N-Gain Percentage for Each Critical Thinking

Critical Thinking Indicators	Experiment Classes		N-gain (%)	Criteria	Control Classes		N-gain (%)	Criteria
	Pretest	Postest			Pretest	Postest		
Providing a simple explanation	9,8	16	60	Medium	10	11	14	Low
Building basic skills	13	18	65	Medium	13	13	2,6	Low
Making conclusion	12	17	67	Medium	8,4	15	49	Medium
Making futher explanation	8,8	17	75	High	10	15	48	Medium
Strategy and tactics	7,6	18	80	High	6,8	13	39	Medium

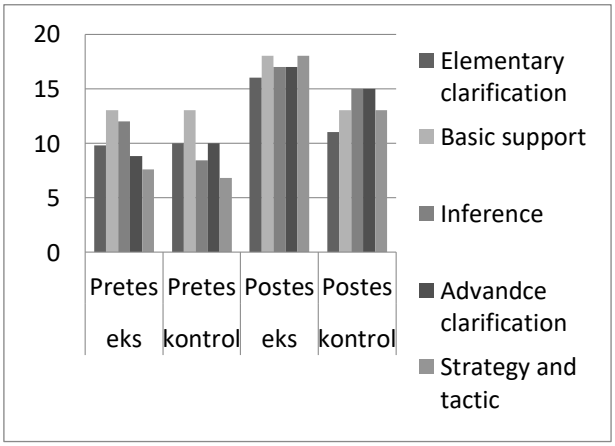

Fig 1. N-gain per Critical Thinking Skills indikator

Table 8 and Figure 1 demonstrate that students' proficiency in answering the critical thinking skills test's indicators has improved across all classes. Critical thinking abilities were better measured in the experimental group compared to the control group on average. lease follow the formatting instructions for headings given in Table 1.

Discussion. Students' critical thinking abilities improved from an average *pre-test* score of 51.72 to 67.28 in the control group, and from 50.84 to 85.44 in the experimental group. In the optical equipment material class at Class XI MIA, Semester II, SMA N 1 Kisaran, there is a statistically significant difference between the control class using the conventional model and the experimental class using the PjBL model, according to *t*-test results.

The first stage of the PjBL model is to find ideas about the problems contained in the LKPD. The assignment pushes students to seek out relevant material in order to generate ideas. Related physics subjects are the focus of the search, and more information is needed from a variety of sources. This phase trains students to take the information they receive wisely and according to their needs. After being given treatment, students' skills in providing simple explanations and analyzing arguments increased by 60%.

The second stage is designing the project, the researcher explains that each group must create a planning schedule for task work, division of tasks and an agreed deadline for project completion. At this stage students' critical skills are trained where students plan to design a project, namely by making a mini proposal listed on the LKPD, trying to investigate and conclude something that will be implemented. Students start to formulate plans and strategies in groups, including things like breaking down the job into manageable phases, gathering inexpensive resources, splitting up the labor so it doesn't take too long, and figuring out what needs doing. They're going to make it happen. all at once. The pupils' ability to think strategically and tactically improved by 80%.

The third phase is preparing the project, the researcher distributes Student Worksheets or *Lembar Kerja Peserta Didik* (LKPD) which presents a project planning proposal that students will make. Researchers also provide explanations regarding the information students need to complete the project, for example where to find the tools and materials needed. During this stage, students learn to think creatively and implement new ideas in order to come up with a final product. While many of the products students make have a similar appearance, they vary in important ways, such as the way they decorate them. Here, students learn to draw conclusions on the project's execution based on a variety of perspectives. Students' ability to draw conclusions has improved by 67% after the therapy.

Carrying out the project is the focus of the fourth stage. In this step, students collaborate to turn their ideas into a working product that addresses the issue at hand. As a result of these exercises, students develop their critical thinking abilities by figuring out what to do to put the idea into action and coming up with creative solutions to the problems that arise. Ability to provide further explanations and organize tactics and plans after therapy is 75% and 80%, respectively.

Finally, the product is evaluated via researcher observations, LKPD reports, and presentations. After receiving a collection of project results for each group, the originality of each group can be identified through the results of their discussions. At each meeting, it was found that there were several product ideas that were similar between one group and another. However, there are still certain things that are different. All groups take turns presenting the results of their projects. Students understand the purpose of presentations is to practice the ability to convey information in public, this starts with a presentation in front of the class

According to the N-Gain exam, students' critical thinking abilities improved by 70% in the experimental class and by 32% in the control class. Compared to traditional methods of instruction, students whose lessons use the PjBL model demonstrate a considerable improvement in their critical thinking abilities. N-Gain analysis revealed that students' critical thinking abilities improved by 70% in the experimental group and by 32% in the control group; furthermore, there was an 80% rise in N-Gain for each critical indicator derived from strategy and tactics. This can be seen from groups of students in determining the strategies and tactics they will use to make a project, namely using materials that are cost-effective and the process does not take a long time, such as in the loop material, there are groups that use simple materials to make loops, namely by using clear glass bottles according to them this is done because if a clear glass bottle is filled with water it will be convex, convex glass can collect sunlight and will result in the glass bottle being like a loop, there are also groups who use used materials to make a loop, namely by using a ball used lamp filled with water. Students in groups also divide tasks during project creation, compiling and identifying work steps in a joint mini proposal. The lowest increase was in the *elementary clarification* indicator with an increase of 60%. Students are less able to answer questions on the question instrument using clear arguments, some students can answer using clear arguments. Students' critical thinking abilities are enhanced more rapidly when taught utilizing the PjBL paradigm compared to traditional methods.[7],[10], and [11] all found that PJBL improved learning outcomes and critical thinking. Development of students' analytical, creative, and genetic reasoning abilities via the use of project-based physics education. The ability to think critically may be enhanced via project-based learning, according to text.

Researchers used traditional learning strategies in the control group. Students in the control group did not engage in project-based learning. Also, the class doesn't work in groups. The only things that students do in optics class are attend to lectures, take notes, and do homework. The five signs of poor critical thinking—a lack of training in fundamental skills, presenting oversimplified explanations, drawing conclusions, and offering further explanations—are brought about by this.

4 Conclusions

Results from the study conducted at SMA N 1 Kisaran T.P. in 2022/2023 show that the *project-based learning* approach had an effect on students' ability to think critically about optical instrument content in class XI, during the second semester.

Following up on this study's findings, future researchers are encouraged to optimize classroom management, develop more reliable research instruments, and gather all necessary resources in advance.

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