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Investigating the Impact of STEM Learning on Students' Critical Thinking Skills through Hand-Made Projector Activity

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ABSTRACT This research presents an investigation on the utilization of Science, Technology, Engineering, and Mathematics (STEM) with Project-Based Learning as experiment class treatment and project-based learning as control class treatment to investigate students' critical thinking in optical instruments lessons, with a particular focus on the development of handmade projectors. In Indonesian schools, where there is a lack of integration of the STEM and learning activity itself, it is still in the form of a direct transfer of knowledge from teachers to students. This research used quantitative research with a quasi-experimental design. The method for data collection is purposive random sampling. The research participant consists of 60 eighth-grade middle high school students in Bandung chosen based on a purposive random sampling technique. The data is obtained through five open-ended essay questions about critical thinking skills. The result shows that the independent t-test for students' critical thinking is 0.081, which means there are no significant differences between the control and experiment classes. However, in the STEM Project-based learning model, The N-gain of students' critical thinking skills is 0.718, which is a high improvement. Moreover, on Project-Based Learning, the N-gain of students' critical thinking skills is 0.660, which is a medium improvement.

Keywords Critical thinking skills, Project-based learning, STEM learning

1. INTRODUCTION

In the 21st century, marked by transformative global changes driven by scientific information, mathematical reasoning, engineering skills, and technology knowledge, there is a pressing need to cultivate proficient human resources. This imperative arises from the realization that human survival hinges not solely on knowledge but also on diverse skills and aptitudes.

Some countries have started to modify their educational systems to improve them. Hong Kong is a representative case of a country that altered its educational guidelines and practices regarding the utilization of technology and engineering math in teaching and learning strategies as a result of the competitive situation in education. (Wan, So, & Zhan, 2022). Technology significantly influences the development of science, particularly the "advancement of science" (physics, chemistry, and biology). Teachers or educators have created a variety of systems and strategies for incorporating technology into the learning process. One example of how technology is employed in learning strategies is the creation of student projects.

Science, Technology, Engineering, and Mathematics (STEM) learning emphasizes the integration of various disciplines into a cohesive and interconnected educational framework. Instead of teaching these subjects in isolation, STEM learning combines them to reflect the way these fields naturally intersect in the real world. This multidisciplinary approach promotes critical thinking, problem-solving, and innovation by encouraging students to draw connections between different areas of knowledge. It prepares learners to tackle complex challenges by applying a blend of scientific principles, technological tools, engineering practices, and mathematical reasoning, fostering a deeper understanding and appreciation of how these domains work together to drive progress and

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innovation. STEM education serves as a conduit for students to cultivate and refine the multifaceted proficiencies required in this era. These proficiencies encompass cognitive capacities and vital soft skills that complement the demands of the 21st century (Bybee, 2010; Erozkan, 2016).

Students are more involved in critical thinking skills when working on projects that incorporate scientific information, mathematical reasoning, technology knowledge, and engineering skills because they may interpret the results of projects (Han, Kelley & Knowles, 2023; Ijirana, Aminah, Supriadi, & Magfirah, 2022; Shahali, Halim, Rasul, Osman, & Zulkifeli, 2017; Tati, Firman, & Riandi, 2017; Triana, Anggraito, & Ridlo, 2020). STEM learning immerses students in a multifaceted learning experience where they must apply theoretical knowledge to practical tasks (Ijirana, Aminah, Supriadi, & Magfirah, 2022). For instance, students draw on scientific principles to understand the underlying mechanics and behaviors of their project. (Han, Kelley & Knowles, 2023; Triana, Anggraito, & Ridlo, 2020). Students employ mathematical reasoning to measure, calculate, and optimize various aspects of their design. (Hanif, Wijaya & Winarno, 2019; Tati, Firman, & Riandi, 2017; Wahono, Lin, & Chang, 2020). Technological knowledge is crucial as they select appropriate tools and materials, understand the functionalities of different components, and incorporate relevant technologies into students' products. Engineering skills come into play when students assemble the prototype, address design challenges, and iteratively refine their work. (Hanif, Wijaya & Winarno, 2019; Turner, Logan, & Wilks., 2022). Throughout this process, interpreting the results of their projects becomes a critical exercise in evaluation and critical thinking skills. (Liu, Sheng & Zhao, 2022; Reynders, Lantz, Ruder, Stanford & Cole, 2020; Sumarni & Kadarwati, 2020; Wilson, Song, Johnson, Presley, & Olson, 2021). Students must analyze the performance of their prototype, identify any discrepancies between expected and actual outcomes, and make data-driven decisions to improve their design. (Hanif, Wijaya & Winarno, 2019). These hands-on activities not only reinforce students understanding of theoretical concepts but also cultivate a comprehensive skill set that is vital for innovation and critical thinking skills (Wilson, Song, Johnson, Presley, & Olson, 2021).

Students' critical thinking and skills are becoming the references pertaining to the assessment of international educational quality through the International Student Assessment Program (PISA) level standard in the education aspect. The PISA assessment was cited to measure students' awareness, students' critical thinking, students' collaboration, and students' abilities in reading, science, social, and mathematic. (OECD, 2019). Critical thinking skills encompass the ability to solve problems, make informed decisions, analyze and evaluate information, and practice evidence-based communication. Critical thinking is reasonable and reflective thinking, emphasizing the importance of focusing on beliefs and decisions. Furthermore, critical thinking, reasoning, reflection, and science process skills are integral activities that promote the development of thinking skills, which are the central goals of science education. When students are able to think critically and reason effectively, they can apply their knowledge to new and unfamiliar situations (Lestari & Annizar, 2020). This adaptability is crucial for their overall academic success and ability to navigate everyday life challenges. Another research suggests that students who are trained in critical thinking are more likely to achieve success in their learning process. (Widodo & Kaniawati, 2024). Moreover, the ability to think critically prepares students to solve real-world problems, equipping them with the skills needed to succeed in various aspects of life. (Cahyono, Rohman, Setyawati & Mustaghfiroh, 2022).

By fostering critical thinking skills, educators can help students develop a mindset that is not only analytical but also reflective and evidence-based. This approach ensures that students are not merely passive recipients of information but active participants in their own learning journey. They learn to question assumptions, evaluate evidence, and make decisions that are informed by careful analysis and reasoning. This holistic development of critical thinking skills is essential for students to thrive in an increasingly complex and information-rich world, where the ability to adapt and innovate is highly valued.

However, in the 2018 PISA (Program for International Student Assessment) data organized by the OECD (Organization for Economic Co-operation and Development), Indonesia is ranked 73 out of 78 countries involved. This low ranking is indicative of broader issues, particularly concerning the development of students' critical thinking skills. Indonesia's position near the bottom of the PISA rankings suggests that students are struggling to meet international benchmarks in reading, mathematics, and science, which are key areas assessed by PISA. Due to students' lack of critical thinking abilities, students may not have a strong foundation in basic subjects like mathematics and science from earlier grades, making it difficult for them to grasp more advanced STEM concepts. (Mutakinati, Anwari, & Yoshisuke, 2018); for educators, a challenging task lies in designing an educational framework that seamlessly integrates knowledge and skills. Segregating the teaching of skills and information throughout the learning process runs the risk of leaving students with an incomplete educational experience. STEM learning entails the simultaneous utilization of both knowledge and skills (Çevik, 2018). One of these issues is that students have a diminished capacity for critical thinking beyond the classroom; the government is addressing this issue by carrying out outreach initiatives focused on the implementation of *Kurikulum 2013* and *Kurikulum Merdeka*. These efforts involve utilizing diverse media platforms for educational learning management system. (Kemendikbud, 2020).

Critical thinking skills need to be continuously honed throughout the learning process. The goal is to produce competent and skilled learners capable of solving everyday problems. Critical thinking skills are not only applied within the realm of education but also require support through assessment tools that can measure the level of critical thinking skills students possess. Based on the fact that the average score of Indonesian students' critical thinking abilities is still below the world average countries. This can be interpreted as students only being able to remember rather than implementing the scientific skills acquired to solve daily-life problems (Aydin, 2020). Students' critical thinking skills require a lot of planning and decision-making in relation to project objectives, labor allocation, timeframes, and schedules, as well as resource identification.

Because of this situation, one of the strategies in the teaching and learning process to enhance students' critical thinking is using STEM Project-Based Learning in making handmade projectors. The study of STEM project-based learning incorporates knowledge and skills from math, science, technology, and engineering. STEM education may improve the quality of human resources while preparing students for professions in a range of sectors (Wieselmann, Sager & Price, 2022). These transdisciplinary STEM subjects give students the possibility to understand problems that happen in real-world situations (Novak & Wisdom, 2018).

STEM project-based learning is an effective learning model because of collaborative activities, development strategies, design processes, and multidisciplinary training. There are five phases of STEM project-based learning, which served as the basis for the stages used in this research are: (1) the stage of preparation, students will make a group, students must recognize and understand the project theme and scope of lesson, and students find information from the internet regarding the fundamental concept of making the projects; (2) the stage of implementation, students produce design drawing, students will discuss tools and materials that will be used, students should make the project based on the concept drawing design, and students should conduct an actual observation and test of their products; (3) The stage of presentation, every group should presents their products and the basic concept behind the products; (4) the stage of evaluation, students will conduct peer evaluation in form of giving suggestion to other groups regarding another group's products and the teacher gives an evaluation regarding the students' product; (5) the stage of correction, students make self-correction and sel-reflection about the product according to suggestions and feedback.

Several studies have observed the impact of Science, Technoogy, Engineering, and Mathematics (STEM) could be effective in enhancing students's critical thinking skills. (Hebebci & Usta, 2022; Ijirana, Aminah, Supriadi, & Magfirah, 2022; Reynders, Lantz, Ruder, Stanford & Cole, 2020). Previous research reported there is a significant effect on senior high school students' problem-solving skills, scientific creativity, and critical thinking disposition after the implementation of STEM learning (Hebebci & Usta, 2022); further research showed that the critical thinking abilities of undergraduate chemistry students by doing team-based STEM-Metacognitive activity during the COVID-19 pandemic are significantly higher than conventional learning (Ijirana, Aminah, Supriadi, & Magfirah, 2022); more research shows the significant impact of undergraduate students' informational thinking processing in STEM courses. If previous studies investigate students' critical thinking skills in senior high school and undergraduate level using team-based STEM activities (Hebebci & Usta, 2022; Ijirana, Aminah, Supriadi, & Magfirah, 2022; Reynders, Lantz, Ruder, Stanford & Cole, 2020). However, it will investigate students' critical thinking skills in Indonesian Middle Schools with a quasi-experimental research design. According to the explanation above, there is much research on STEM project-based learning with different findings, samples, and research methods. Hence, the research problem of this research is "How does the effect of STEM-Project Based Learning on students' critical thinking skills after creating a handmade projector?".

2. METHOD

2.1 Research Method

The research approach employed in this study involves quantitative research with quasi-experimental research model utilizing a pre-test and post-test control group design. Quantitative research involves the evaluation of objective hypotheses through the analysis of connections between measurable variables. This is accomplished by employing instruments to gather numerical data, which is subsequently subjected to statistical analysis (Creswell, 2009). This approach aligns well with the research goals of this study. According to Creswell (2009) quasi-experimental research model is referred to as pseudo-experimentation, aimed at predicting conditions that can be achieved through actual experiments, yet without full control and/or manipulation of all relevant variables. In this context, two classes were selected the control group and the experimental group. According to pre-test and post-test control group design is the pre-test and post-test control group design is a research design that involves conducting measurements on two separate groups: an experimental group and a control group. The quasi-experimental design is represented in Table 1.

Table 1 Quasi-experimental design

Group	Pretest (O_1)	Treatment	Posttest (O_2)
Experiment class	O1	X	O2
Control class	O1	-	O2

2.2 Participant

This study aims to investigate critical thinking skills and collaborative skills after the application of STEM project-based learning tests on the topic of Optical Instruments. Therefore, the participants in this research are middle high school students who have not studied Optical Instruments before. The research was conducted in private middle high schools in Bandung, involving a total of 60 participants aged 13-14 years (30 males) in the control class and 30 participants (30 males) in the experiment class. Research participants were selected using purposive sampling, a sampling technique based on specific considerations. More information, purposive sampling is a method of selecting a sample in which the researcher goes beyond simply working with available individuals, instead using their informed judgment to choose a sample they deem appropriate based on their prior knowledge (Fraenkel, Wallen, & Hyun, 2011). Considerations guiding participant selection included budget, resources, and time. The participant distribution can be seen in Table 2.

Table 2 Sample and population distribution

Group	Students	Gender	Total
Experiment class	30	Male	60
Control class	30	Male	

2.3 Research Instrument

This research requires the use of research instruments to collect the data. There is one type of research instrument that will be used in this research paper, which is an objective test with open-ended essay questions. The research instrument was used to collect the data needed in this study. The research instrument used is five open-ended essay questions about critical thinking that were developed by Ennis (2018). The data that was collected from students' critical thinking skills is based on the product that was made by students during the STEM project-based learning process. The indicators of critical thinking skills used in this research are adopted (Ennis, 2018), who stated that the critical thinking test consisted of five open-ended essay questions. The objective test covered five aspects of Critical Thinking Skills Indicators. The Skill indicators are Basic Clarification / Analysing arguments, Basic for a decision / Use of existing knowledge, Inference / Making and judging inductive inferences and arguments, Advanced clarification / Defining terms, and judging definitions and non-Constitutive. This test is helpful, but rhetorical strategies are needed. This objective test was first tested on the aspects of validity, normality, and reliability. This test has also been judged by three experts on the subject and, therefore, has fulfilled the requirements for a valid objective test for students' Critical Thinking Skills on the topic of light and optics. A statistical test was carried out to determine the Critical Thinking Skills in the class being treated based on the difference in the outcome of their pre-test and post-test. The scoring rubric for these open-ended essays can be seen in Appendix.

2.4 Research procedure

As previously stated in the research method, this quasi-experiment uses matching only the pretest and posttest control group design. It will use deciding stage, implementing stage, and evaluation stage. The research procedure started with the deciding stage, which was to find and formulate the research problems. After that, a literature review will be conducted about the STEM approach, STEM project-based learning, project-based learning, and students' critical thinking skills in learning science. The stage continues with making the instruments, which consist of students' critical thinking skills and collaborative skills. After that, the instrument will be validated by the expert's judgment, and a revision will be done directly. After revision, the instrument is validated by the students to know whether the instrument can be used or not for the next stages. The last thing to do in this stage is to make a lesson plan along with the learning media, worksheet, and teaching device needed. The implementation of treatment in making a handmade projector for the 8^{th} grade of Middle High School in the control class. In this research, the learning activities have been conducted in six meetings; a pre-test was conducted along with the first meeting, followed by the fourth meeting related to the implementation of Project-Based Learning and STEM project-based learning, with a duration of 2 x 45 minutes for each meeting. In the second meeting, the control class formulated group project plans and applied the project, whereas the experiment class conducted the preparation and implementation stages. In the third meeting, the control class still applied the project, whereas the experiment class still conducted the implementation stage. Fourth meeting, students in the control class conduct planning the presentation, presentation, and evaluation, whereas students in the experiment class conduct a stage of presentation, stage of evaluations, and stage of correction. Fifth meeting, students in both classes conduct the generalization stage, whereas teachers explain the topic of optical instruments. Furthermore, at the last meeting, students in both classes conducted a post-test. The second research procedure, namely the implementation stage, consists of doing the

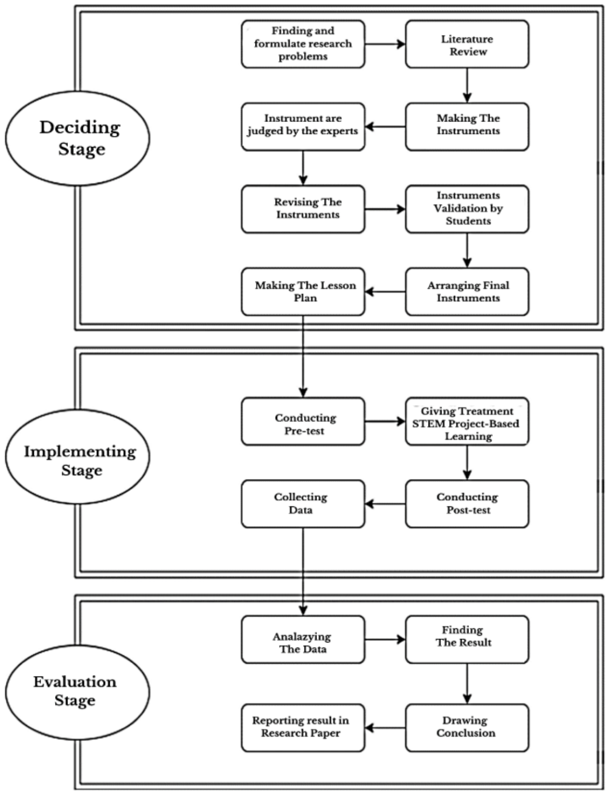


Figure 1 Scheme of research procedure

implementation in the class and giving students pre-tests and post-tests. The detailed activities of implementation, excluding pre-test and post-test in the classroom, can be shown in Table 3.

The third one is the completion stage, in which the researcher collects and calculates the data to further analyze the data and find the result. From the result, the researcher will continue to make a conclusion. The data collected are analyzed statistically and written in the form of a research paper. Furthermore, the flow chart of the research procedure is shown in **Figure 1**

3. RESULT AND DISCUSSION

3.1 The Effect of STEM Project-Based Learning on Students' Critical Thinking Skills

Students' critical thinking skills are assessed by giving all participant students in the control and experiment class an essay test twice. The first time the test was given before implementing the treatment, it was called a pre-test, and the second time after implementing the treatment, it was called a post-test. The research was conducted on the aforementioned pre-test and post-test in a private Middle high school in Bandung.

The indicators of critical thinking skills used in this research are adopted (Ennis, 2018) who stated that the critical thinking test consisted of five open-ended essay questions. The essay test covered five aspects of Critical Thinking Skills Indicators. The Skill indicators are Basic Clarification / Analysing arguments, Basic for a decision / Use of existing knowledge, Inference / Making and judging inductive inferences and arguments, Advanced clarification / Defining terms, and judging definitions and non-Constitutive. This test is helpful, but rhetorical strategies are needed. This essay test has been tested first on the aspects of validity, normality, and reliability. Three experts on the subject have also judged this test and, therefore, has fulfilled the requirements for a valid essay test for students' critical thinking skills on the topic of light and optics. A statistical test was carried out to determine the Critical Thinking Skills in the class being treated based on the difference in the outcome of their pre-test and post-test. The summary of Students' Critical Thinking skills in the control class and experiment class can be seen in Table 4.

Based on Table 4, the average score in the control class is 31.94 (SD 9.59), interpreted as an unreflective thinker for the pre-test, and 76.38 (SD 9.07), interpreted as a practicing thinker for the post-test. Meanwhile, the average score in the experiment class is 32.60 (SD 9.59), interpreted as an unreflective thinker for the pre-test, and 80.40 (SD 8.43), interpreted as a practicing thinker for the post-test. The average scores before and after implementing treatment in both classes show an increasing trend. This finding is further explained by other results of the lowest and highest scores in both classes, which show a similar increasing trend. Figure 2 shows the average score of students' critical thinking skills in both classes.

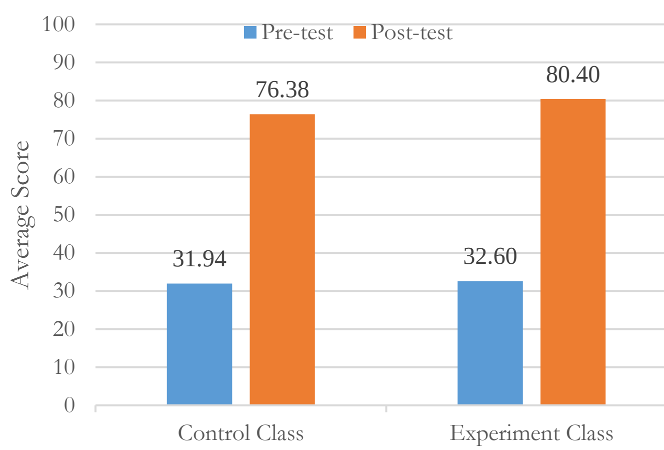


Figure 2 Average Score of Students' Critical Thinking Skills

Figure 2 confirms the finding in Table 5, which shows the increasing trend in the average score of Critical Thinking Skills that students achieved before and after participating in the learning treatment. Then, it can be interpreted that the implementation of treatment in learning activities is effective to increase students' critical thinking skills.

To support the above finding and interpretation, homogeneity test is needed, since the more valid

Table 3 Activities in control class and experiment class

Experiment Class		Control Class	
STEM Project-Based Learning Stages	**Activities**	**Project-Based learning Stages**	**Activities**
The stage of preparation	Students make a group Students acknowledgethe project theme and scope about optical instruments and handmade projector Students find information from the internet and science books regarding the basic theory of making handmade projector	Formulation of group project plans	Students make a group Students acknowledgethe project theme and scope about optical instruments and handmade projector Students find information from the internet books regarding the basic theory of making handmade projector
The stage of implementation	Students making handmade projector design based on the group discussion Students discuss tools and materials that will be used Students make the project based on the design drawing	Applying the project	Students making handmade projector design based on the group discussion Students discuss tools and materials that will be used Students make the project based on the design drawing
The stage of presentation	Students conduct an actual test of their product, consist of measuring the focal length of lens, mentioning the characteristic of image formation, and making conclusion. Each group present their product and concept foundation behind the product	Planning the presentation	Students conduct an actual test of their product consist of measuring the focal length of lens, mentioning the characteristic of image formation, and making conclusion.
The stage of evaluation,	Students conduct peer evaluation regarding another groups' product Teacher gives an evaluation regarding students' product	The presentation	Each group present their product and concept foundation behind the product
The stage of correction	Students make self-correction about the product according to suggestion and feedback. Furthermore, students start to revise the handmade projector based on suggestion before.	The Evaluation	Teacher gives an evaluation regarding students' product

Source: (Bilgin, Karakuyu & Ay, 2015; Lou, Chou, Shih & Chung, 2017).

Table 4 Summary of students' critical thinking skills score

Component	Control Class		Experiment Class	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
Participant	30	30	30	30
$\bar{x}$	31.94	76.38	32.60	80.40
(Interpretation	Unreflective thinker	Practicing Thinker	Unreflective thinker	Practicing Thinker
SD	9.59	9.07	8.39	8.43
Highest score	46.90	93.80	46.90	93.80
Lowest score	20.10	60.30	20.10	60.30

Table 5 Normality of students' Critical Thinking Skills

Component	Control Class		Experiment Class	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
Normality test (Kolmogorov-Smirnov)	0.053	0.085	0.062	0.070
Interpretation	Normal	Normal	Normal	Normal

conclusion can be drawn from a homogenous sample or population. Homogeneity can be applied through the use of Normality Test, in which this research takes from Kolmogorov-Smirnov Test and Lavene Test. Results of homogeneity is shown in Table 5 (Kolmogorov-Smirnov Test).

Based on Table 5 the output of the normality test (Kolmogorov-Smirnov test) in the control class is 0.053 for the pre-test and 0.085 for the post-test result. Meanwhile, the normality test (Kolmogorov-Smirnov test) in the experiment class is 0.062 for the pre-test and 0.070 for the post-test. It can be interpreted that the normality test (Kolmogorov-Smirnov) is more than 0.05 which means the data are normally distributed. Table 6 describes the homogeneity of students 'critical thinking results.

Furthermore, based on Table 6, the output of the homogeneity test (Levene test) is 0.362 for the pre-test and 0.382 for the post-test result. It can be interpreted that the homogeneity test is more than 0.05 which means the data group comes from a population that has the same variance (homogenous). In addition, to find out how likely the difference between the data of independent groups exists, an independent t-test is applied. This is because the value of one sample does not reveal any information about the value of another sample. The result of this test is described in Table 7.

Table 7 shows that the output of the independent t-test is 0.774 for the pre-test and 0.081 for the post-test result. In pre-test results, students in both classes did not study light and optics. Unlike in the pre-test, the post-test result shows that both classes have learned lights and optics. The result further explains that the significance level is more than 0.05, meaning that the null hypothesis (H_0) is accepted. Such finding means there are no significant differences between the control class and the experiment class both in the pre-test and post-test. This is due to the fact that in the learning process, both groups have the same project and the same learning procedures. Moreover, to ensure the similarity of data that has been recorded or to maintain data integrity and truth, the normalization data or N-gain test is employed. More information about the results of the N-gain test is shown in Table 8.

In order to know the value of the enhancement, the N-Gain or Normality Gain test was done based on (Hake, 1996). Table 8 indicates a normalized gain in control class improved in each aspect of students' Critical Thinking

Table 6 Homogeneity of students' critical thinking skills

Component	Pre-test		Post-test	
	Control Class	**Experiment Class**	**Control Class**	**Experiment Class**
$\bar{x}$	31.94	32.60	76.38	80.40
Homogeneity test (Levene test)	0.362		0.382	
Interpretation	Homogenous		Homogenous	

Table 7 Independent t-test of students' critical thinking skills

Component	Pre-test		Post-test	
	Control Class	**Experiment Class**	**Control Class**	**Experiment Class**
$\bar{x}$	31.94	32.60	76.38	80.40
Independent t-test Significance (2-tailed)	0.774		0.081	
Interpretation	No significance		No significance (H_0 is accepted)	
Conclusion	No significance difference		No significance difference	

Table 8 N-gain of students' critical thinking skills

Component	Control Class		Experiment Class	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
$\bar{x}$	31.94	76.38	32.60	80.40
Normalized N-gain	0.660		0.718	
Interpretation	Medium		High	

Table 9 Integration of STEM in making handmade projector

STEM Learning Approach Science (S)	Technology (T)	Engineering (E)	Mathematic (M)
Identify the characteristic of image formation in lens	Find information from the internet, decide the materials and tools, and conduct the actual test.	Drawing handmade projector design.	Magnification Calculation

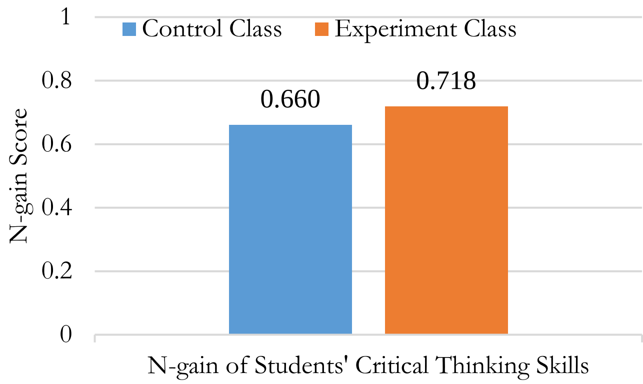


Figure 3 N-gain of students' critical thinking skills

Skills through the implementation of Project-Based learning since the N-gain reveals 0.660. Similarly, normalized gain in the experiment class also increased in each aspect of students' Critical Thinking Skills by implementing STEM Project-Based learning, due to the fact that N-gain values 0.718. The N gain score in the control class and experiment show an increasing trend. Figure 3 shows the N-gain of students' critical thinking skills.

Figure 3 shows the N-gain score of Critical Thinking Skills that students achieved in the control class and experiment class. Then, it can be interpreted that the implementation of Project-Based Learning in a control class is effective to increase students' Critical Thinking Skills to the medium level. Meanwhile, the implementation of STEM Project-Based Learning in experiment classes is effective in increasing students' Critical Thinking Skills to a high level. This result is because of the different treatments, STEM Project-Based Learning experiment class, and Project-Based Learning in the control class, which are the reasons for this result. In this study, students will make a handmade projector based on the STEM approach. The integration of STEM in making handmade projector activities can be presented in Table 9.

Table 9 shows the context of this research, the science (S) aspect revolves around exploring the concept of image formation within lenses. Prior to crafting the handmade projector, students are required to comprehend how images are shaped by both convex and concave lenses. A solid grasp of image characteristics empowers students to select the appropriate lens for constructing the handmade projector. Within this framework, students are expected to determine the ideal length or curvature of the lens, thereby ensuring that the handmade projector yields a genuine and magnified image. The technology (T) component manifests during various stages. During the preparation phase, students access online resources or scientific literature related to lens-based image formation, acquiring essential information for the handmade projector creation. This phase also entails making choices regarding tools and materials. The technology element continues into the implementation stage, where students carry out practical tests to validate the functionality of their handmade projectors. Engineering (E) considerations come into play during both the preparation and implementation phases. Students engage in designing their own blueprints, aligning them with the principles of image formation in lenses. Detailed design drawings aid the construction process, incorporating crucial information such as focal lengths, lens types, and object distances. Mathematics (M) involvement centers on the magnification of images produced by the handmade projector. Students apply relevant formulas to calculate the magnification achievable through their handmade projectors.

Beginning with the stage of preparation, students were asked to make three groups containing 9 – 10 students for each group. They triggered their prior knowledge of the topic, fulfilled their individual or group work, determined materials, and created a product design for each group. The researcher gave the students instructions on how to make a handmade projector. Afterward, students start to discuss the project planning within the group. In this process, students have to find information related to handmade projectors on the internet or in science books. Therefore, the researcher put several information to help students hit the target. (Ennis, 2018).

From this information, students will imagine that they are really becoming the students who need to solve the problem of making handmade projectors. The criteria and limitations of the tool stated in the problem are to challenge students to make handmade projectors with the criteria and limitations using environmentally friendly tools and materials. Thus, it is essential to the stage of preparation at the beginning of STEM project-based learning. According to Mutakinati, Anwari, & Yoshisuke (2018) the purpose of the stage of preparation is not only to make the tool but also to trigger students' prior knowledge of the topic, fulfill students' group work, determine materials, and create a product design for each group. During the stage of preparation, students are presented with the chance to explore issues and acquire necessary information for problem-solving, either from textbooks or online sources. This aligns with the perspective of Gandi, Haryani, & Setiawan, (2021) who assert that critical thinking can flourish when students have the freedom to investigate in an unstructured setting. Moreover, the stage of preparation facilitates group discussions among students to identify pertinent project-related information gathered from the internet. These discussions serve as a catalyst for students to articulate their thoughts, a concept supported by Havita, (2020) who highlight the multiple benefits of discussions in stimulating students' critical thinking and expression of ideas.

In the stage of implementation, the participant students were told to make designs about the handmade projector

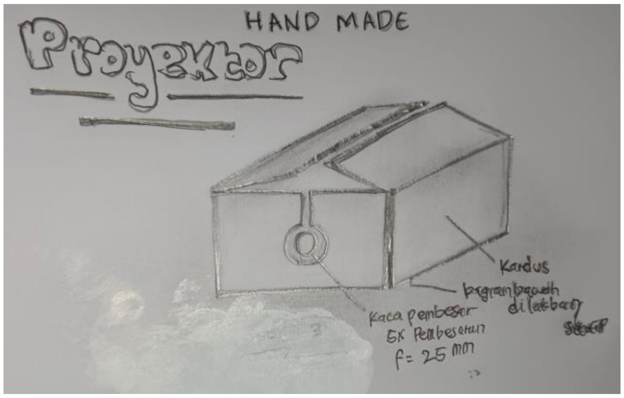


Figure 4 Design drawing of handmade projector

Figure 5 Actual handmade projector

Figure 6 Students presenting the result

Figure 7 Initial and final handmade projector

by drawing it and to prepare the required materials on the basis of the designs they had made. During the stage of implementation, students engage in practical experimentation to bring their project design and start to create the handmade projector. Additionally, they perform actual tests to ensure the functionality of their handmade projector. Critical thinking skills can evolve through hands-on experiments and collaborative discussions among students. (Ijirana, Aminah, Supriadi, & Magfirah, 2022). At this stage, the students make initial design based on the information selected. The students sketched and drew their designs in their worksheets, as shown in Figure 4.

Figure 4 shows the design of a handmade projector throughout the stage of implementation; students must make decisions about design modifications, component choices, and adjustments. Critical thinking enables them to weigh the pros and cons, considering how each choice impacts the projector's performance. They analyze technical issues, troubleshoot errors, and devise innovative solutions to ensure the projector works effectively (Ennis, 2018). The students created their designs to become the actual product of a handmade projector, as shown in Figure 5.

Figure 5 shows the actual handmade projector. Continuing with the stage of presentation, participant students share their duties of directing the presentation, performing their explanation, coping with questions in case there were any, and generalizing their presentation about

Table 10 Data collection result

Group	Distance of Image (Si)	Distance of object (So)			Image formation
		1	2	3	
Group 1 (2x magnification with f = 100 mm)	30 cm	5 cm	10 cm	15 cm	No image
Group 2 (5x magnification with f = 25 mm)	30 cm	5 cm	10 cm	15 cm	Image can see clearly if the is object placed at 5 cm
Group 3 (5x magnification with f = 50 mm)	30 cm	5 cm	10 cm	15 cm	Image can see if the object is placed at 10 cm but not clear

the project they have made – a handmade projector. In the stage of presentation, students try to communicate their product and also their design. Students expressed some trouble that they faced while working on the project. In addition, in this stage, students also conduct an actual test of their product. Table 10 documented how students tested the handmade projector.

As it is known expressive is one criterion of elaboration dimension. Students should think critically, about how to draw attention when presenting the product. Expressive criteria refer to the product being presented in a communicative way and understandable manner. (Sumarni & Kadarwati, 2020). Figure 6 documented how this stage was conducted.

In the stage of evaluation, each group of participant students, guided by the instructor, evaluated their project based on discussions, insights, or arguments from another group. Here, critical thinking skills are explored. In addition, in the stage of correction, each group of participant students corrected or revised their project of making their handmade projector by changing the size of the lens and the focus coordinate. The activities provided them with a new understanding of the factors that influence their projects' performance.

In the evaluation and correction stages, students made improvements to their products. These stages become a reflection for students to find the best way to improve the quality of the product. Of effective teaching should give students opportunities to reflect on their own critical thinking, receive feedback from other students, and revise thinking as a result of new information freely. stated that effective instruction should provide opportunities for students to evaluate scientific evidence based on their own understanding, connect the theory with their own explanation, and partly participate in learning. In this case, students' critical thinking plays a role in creating an effective solution to repair students' products. Figure 7 shows the revision of the handmade projector.

This research found that both of the treatments, which are STEM Project-Based Learning or Project-Based Learning only, are suitable for increasing the critical thinking skills of students. This is because the result of the independent t-test shows that the significant level for classes is 0.774 for the pre-test and 0.081 for the post-test result. The result further explains that the significance level is more than 0.05, meaning that the null hypothesis (H_0) is accepted. Such finding means there are no significant differences between the control class and the experiment class both in the pre-test and post-test. This is due to the fact that in the learning process, both classes have the same project and the same learning procedures.

However, the comparison of N-gain shows that the experiment class increased in each aspect of students' Critical Thinking Skills by implementing STEM Project-Based learning, due to the fact that N-gain values 0.718, which means a high level. However, the control class improved in each aspect of students' Critical Thinking Skills through the implementation of Project-Based learning since the N-gain reveals 0.660, which means at a medium level. It can be interpreted that the STEM Project-Based Learning model is more suitable for increasing critical thinking skills. The results of this study are in line with previous research that stated that STEM-based project-based learning models can elevate students' critical thinking skills (high), and improve learning outcomes (Afifah, 2019; Kristiyanto, 2020). This result is in line with the improvement of the average score between the pre-test and post-test in the experiment class. The different treatments, STEM Project-Based Learning experiment class and Project-Based Learning in control class, are the reason for this result. This is in line with previous research that said that the STEM Project-Based Learning model influenced critical thinking skills.

Some studies related to the results of improvement stated that the teaching and learning model is one of the factors influencing students' critical thinking skills, especially by using STEM learning that could help students increase their critical thinking and understanding of the concept (Gandi, Haryani, & Setiawan, 2021; Ijirana, Aminah, Supriadi, & Magfirah, 2022; Mutakinati, Anwari, & Yoshisuke, 2018). These findings are also relevant to previous research, learning strategies have the potential to impact critical thinking skills, particularly when the chosen learning approaches are aligned with the inherent attributes of the subject matter (Insyasiska, Zubaudah & Susilo, 2015). The implementation of STEM Project-Based Learning in this research has its own benefit since the participant students have learned the subject of light and optics. This means that participant students know not only the concept of light and optics but also the mechanism of light and optics in daily life. These findings are also relevant to a previous study that described the main material of heat and matters topic found the increase in students' critical thinking skills in the aspects of basic clarification, advanced clarification, and rhetorical strategies for the experimental class was better than the control class (Sumardiana, Hidayat, & Parno, 2019). It is also supported by other research stating that STEM Project-Based Learning has a better effect on the student's mastery of the concept. Based on the results of the observations of the activities during the implementation of STEM Project-Based Learning, it is known that the optimal implementation of STEM Project-Based Learning requires a longer period of time (Havita, 2020). This ensures that all STEM project-based learning activities can be carried out and that students can explore more of the new concepts they have after implementing the project. This is because the characteristics of STEM Project-Based Learning emphasize active and group-based learning as well as sharing information with each other, thus helping to broaden other students' perspectives in

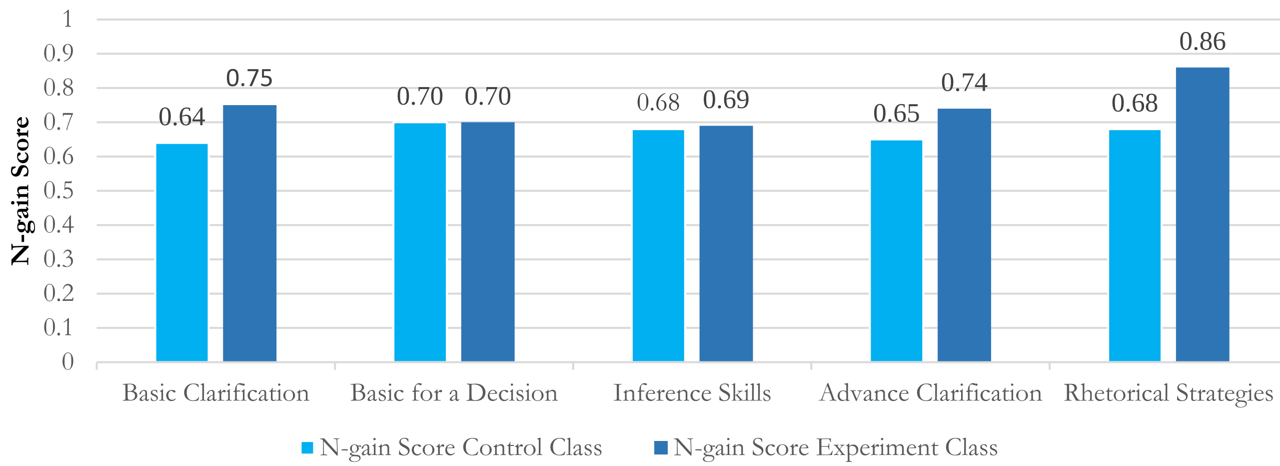


Figure 8 N-gain score in each critical thinking skill indicators

thinking by integrating STEM. Therefore, students gain meaningful and impactful learning experiences as they are directly involved in the learning process (Havita, 2020; Sumardiana (Sumardiana, Hidayat, & Parno, 2019). It is also supported by previous research findings stating that the use of the STEM Project-based Learning model grants students the freedom to discover and solve problems on their own (Mutakinati, Anwari, & Yoshisuke, 2018). The implementation of this STEM project-based learning model, by providing students the freedom to discover and solve problems, can enhance students' higher-order thinking skills, thus making it easier for students to retain the material due to their direct involvement.

3.2 The Effect of STEM Project-Based Learning on Each Indicator of Critical Thinking Skills

With the same procedure as examining students' critical thinking skills through STEM Project-Based Learning implementation, each indicator of critical thinking skills can also be derived. Indicators of critical thinking skills discussed in this research are basic clarification, basic for a decision, inference skills, advanced clarification, and rhetorical strategies. Summary of Critical Thinking Skills

Table 11 Summary of each indicators of critical thinking skills

Class	Component	Basic Clarification	Basic for a Decision	Inference Skills	Advance Clarification	Rhetorical Strategies
Control Class	$\bar{x}$ Pre-test	31.11	31.11	34.44	31.11	30.00
	Interpretation	Unreflective thinker	Unreflective thinker	Unreflective thinker	Unreflective thinker	Unreflective thinker
	$\bar{x}$ Post-test	72.22	76.67	76.67	74.45	80.00
	Interpretation	Practicing Thinker	Practicing Thinker	Practicing Thinker	Practicing Thinker	Practicing Thinker
	N-gain	0.64	0.70	0.68	0.65	0.68
	Category	Medium	Medium	Medium	Medium	Medium
Experiment Class	$\bar{x}$ Pre-test	33.33	30.00	33.33	33.33	34.44
	Interpretation	Unreflective thinker	Unreflective thinker	Unreflective thinker	Unreflective thinker	Unreflective thinker
	$\bar{x}$ Post-test	80.00	76.67	76.67	80.00	88.89
	Interpretation	Practicing Thinker	Practicing Thinker	Practicing Thinker	Practicing Thinker	Advanced Thinker
	N-gain	0.75	0.70	0.69	0.74	0.86
	Category	High	Medium	Medium	High	High
Comparison of Post-test result	Independent t-test	0.142	1.000	1.000	0.325	0.039
	Significance (2-tailed)					
	Interpretation	No Significant	No Significant	No Significant	No Significant	Significant

Indicators in the control class and experiment class can be seen in Table 11.

Furthermore, in order to know the value of the enhancement, the N-Gain or Normality Gain test was done based on the (Hake, 1996). The N gain score in control class and experiment show an increasing trend. Figure 8 shows the N-gain of students' critical thinking skills on each indicators.

The indicator of basic clarification, as mentioned in Table 11, supplies a significant variable in supporting the participant students' critical thinking since the paired t-test of both groups is 0.000. Similarly, indicators of basic for a decision, inference skills, and advanced clarification also indicate that they possess no significant roles or variables in developing the student's critical thinking.

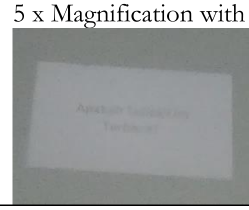
In addition, the comparison of the independent t-test of 4 over 5 the indicators of critical thinking skills, as shown in Table 11, indicates that there are no significant differences in the post-test between the control and the experiment groups. This infers that Project-Based Learning and STEM Project-Based Learning promote increasing development of the participant students' basic clarification, basic for a decision, and advanced clarification. An example to support the above statement, based on Table 11, explains that there is no significant difference in independent t-test scores of advanced clarification post-test scores in both the control and the experiment class. However, there is one indicator that shows a significant difference, which is non-constitutive bus helpful or rhetorical strategies.

Meanwhile, Figure 8 shows the N-gain scores in all indicators of critical thinking skills in the control group are at the medium level, meaning that the project-based learning has positive impacts on increasing participant students' critical thinking skills in the aspects of basic clarification, basic for a decision, inference clarification and rhetorical strategies at medium level. However, the N-gain scores in all indicators of critical thinking skills in the experiment group range from medium to high level. This also tells us that STEM project-based learning increases participant students' critical thinking better than project-based learning.

This research found that both of the treatments, which are STEM Project-Based Learning or Project-Based Learning only, are suitable for increasing the critical thinking skills of students in indicators of basic clarification, basis for a decision, inference, and advanced clarification. This is because the result of the independent t-test shows that the significance is more than 0.05, meaning that the null hypothesis (H_0) is accepted. Such finding means there are no significant differences between the control class and the experiment class both in the pre-test and post-test. This is due to the fact that in the learning process, both two classes have the same project with the same learning procedures and the same questions, and both classes have the same generalization steps, which the teacher gives the materials about optical instruments in both classes.

However, in the comparison of indicators about non-constitutive but helpful full/rhetorical strategies, the significant value result is 0.039, which means it is less than 0.05, resulting in H1 being accepted. It can be concluded that there is a significant difference between post-test results that affect the students' rhetorical strategies. This is because of the differences between the stages of project-based learning in the control class and the stages of STEM project-based learning in the experiment class. In Experiment class, there is the stage of correction where students can make improvements to their product. These stages become a reflection for students to find the best way to improve the quality of the product. Of effective teaching should give students opportunities to reflect on their own critical thinking, receive feedback from other students, and revise thinking as a result of new information freely. The effective instruction should provide opportunities for students to evaluate scientific evidence based on their own understanding, connect the theory with their own explanation, and partly participate in learning. In this case,

Table 12 Comparison Between Initial Project and Revise Project

	Handmade Projector **Initial Handmade Projector**	**Revised Handmade Project**
Product		
Specification	2 x Magnification with f = 100 mm	5 x Magnification with f = 25 mm
Quality of image		

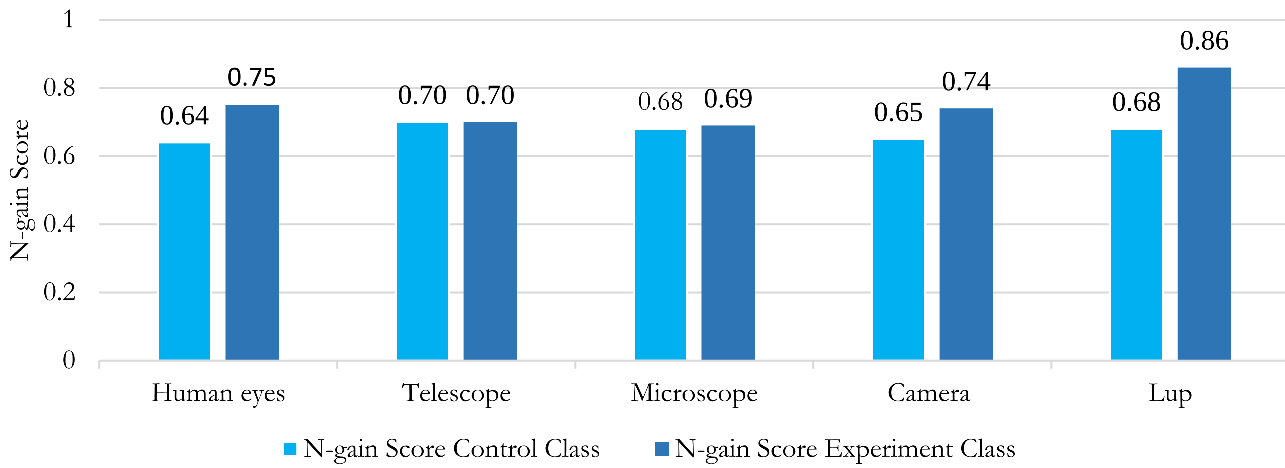


Figure 9 N-gain score in each sub-topic in optical instruments

students' critical thinking plays a role in creating an effective solution to repair students' products (Sumardiana, Hidayat, & Parno, 2019). The summary of project revision done by students can be seen on Table 12.

Table 12 shows the data collection result after students tested the handmade projectors. Based on the table, it can be interpreted that magnification and focal length of magnifying glass can influent the distance and quality of the image. So, some of the groups revised their handmade projectors; students changed the lup with the same characteristics. All of the group choose a magnifying glass with specification 5 x magnification and a focal length of 25 mm. Figure and Figure show the reason why they changed the magnifying glass.

During the stage of implementation, students engage in an experiment to construct the designed product. Additionally, they conduct a practical test to ensure the functionality of their crafted handmade projector. (Mutakinati, Anwari, & Yoshisuke, 2018)asserted that critical thinking skills can be nurtured through experiments and collaborative discussions among students.

Moving on to the stage of presentation, students endeavour to effectively communicate both their product and its design. They candidly address challenges encountered during the project, recognizing that expressive abilities serve as indicators of rhetorical strategies. Consequently, students are prompted to think critically about how to captivate attention while showcasing their product (Kartini, Widodo, Winarno & Astuti, 2021)

The subsequent stages of evaluation and correction involve students making enhancements to refine the handmade projector. These phases serve as opportunities for reflection, enabling students to ascertain the optimal approaches for enhancing the projector's quality. Effective pedagogy necessitates affording students the chance to scrutinize their own critical thinking, receive input from peers, and amend their perspectives in light of new information. (Han, Capraro & Capraro, 2015; Kwon, Capraro & Capraro, 2021; Lee, Capraro, & Bicer, 2019) that impactful instruction facilitates the evaluation of scientific evidence based on individual comprehension, the integration of theory into personal explanations, and active engagement in the learning process. Here, students' critical thinking actively contributes to formulating effective solutions for refining their projects.

3.3 The Effect of STEM Project-Based Learning on Sub-topic of Optical Instruments

With the same procedure as examining students' critical thinking skills through STEM Project-Based Learning implementation, sub-topic of light and optics lesson can also be derived. Sub-topic of light and optics lesson discussed in this research are the human eye, telescope, microscope, camera, and lup. Detailed information about this sub-topic is drawn in Table 13.

Furthermore, in order to know the value of the enhancement, the N-Gain or Normality Gain test was done based on the (Hake, 1996). The N gain score in control class and experiment show an increasing trend. Figure 9 shows the N-gain of students' score in each sub-topic of optical instruments.

The sub-topic of human eye materials, as mentioned in Table 13, shows that it supplies a significant variable in supporting the participant students' concept mastery in light and optic lessons since the paired t-test of both groups is 0.000. Similarly, the sub-topics of telescope, microscope, camera, and lup also indicate that they possess significant roles or variables in developing the participant students' concept mastery.

The comparison of means of all the sub-topics of the optical instruments lesson, as shown in Table 13, indicates that there are significant differences in the pre-test and post-test between the control and the experiment groups. This infers that Project-Based Learning and STEM Project-Based Learning promotes increasing development of the participant students' concept mastery in light and optics.

Table 13 Summary of concept mastery indicators in optical instruments

Class	Component	Sub-Topic Materials				
		Eyes	**Telescope**	**Microscope**	**Camera**	**Lup**
Control Class	$\bar{x}$ Pre-test	31.11	31.11	34.44	31.11	30.00
	$\bar{x}$ Post-test	72.22	76.67	76.67	74.45	80.00
	N-gain	0.64	0.70	0.68	0.65	0.68
	Category	Medium	Medium	Medium	Medium	Medium
Experiment Class	$\bar{x}$ Pre-test	33.33	30.00	33.33	33.33	34.44
	$\bar{x}$ Post-test	80.00	76.67	76.67	80.00	88.89
	N-gain	0.75	0.70	0.69	0.74	0.86
	Category	High	Medium	Medium	High	High
Comparison of Post-test result	Independent t-test Significance (2-tailed)	0.142	1.000	1.000	0.325	0.039
	Interpretation	No Significant	No Significant	No Significant	No Significant	Significant

Meanwhile, Figure 8 tells us that the N-gain scores in all the sub-topics of light and optic lessons in the control group are at the medium level, meaning that Project-Based Learning has a positive impact on increasing participant students' concept mastery in the sub-topic of human eye, telescope, microscope, camera and lup at medium level. Whereas the N-gain scores in all the sub-topics of light and optic lessons in the experiment group range from medium to high level. This also tells us that the experiment class uses STEM Project-Based Learning as the learning model increases participant students' concept mastery more than the control class only uses project-based learning as the learning model.

The results of this research are in line with previous research that stated that STEM-based project-based learning models can elevate students' critical thinking skills (high), and improve concept mastery (Afifah, 2019; Kartini, Widodo, Winarno & Astuti, 2021) This result is in line with the improvement of the average score between the pre-test and post-test in the experiment class. The different treatments, STEM Project-Based Learning experiment class and Project-Based Learning in control class, have become the reason for this result. (Mutakinati, Anwari, & Yoshisuke, 2018) This is in line with previous research said that the STEM Project-Based Learning model influenced the concept mastery in light and optics.

4. CONCLUSION

In the STEM Project-Based Learning model, the N-gain of students' critical thinking skills is obtained as much 0.718, which is categorized as a high level of improvement. However, in the Project-Based learning model, the N-gain of students' critical thinking skills is obtained as much 0.660, which is categorized as a medium level of improvement. Based on the result, STEM project-based learning has a good impact on students' critical thinking skills. STEM project-based learning can be used as alternative teaching strategies in Junior High School.

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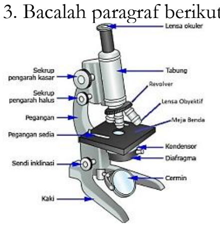
Appendix.

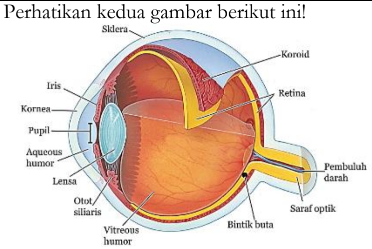
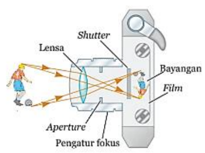
Questions rubric blue print

<table>
<tr><th>No</th><th>Topics</th><th>Questions</th><th>Assesment scoring</th><th>Count</th><th>Point</th><th>Score</th></tr>
<tr><td rowspan="4">1</td><td rowspan="4">Eye</td><td rowspan="4">1. Perhatikan gambar berikut ini!


Roni berasumsi bahwa gambar diatas adalah penderita rabun dekat (Hipermetropi), kacamata dengan lensa cekung akan mengubah titik terbentuknya bayangan menjadi tepat di retina. Bagaimana pendapat anda mengenai asumsi Roni? Jelaskan!</td><td>The student did not answer</td><td>0</td><td rowspan="4">6.7</td><td rowspan="4">20</td></tr>
<tr><td>Incorrect answer and incorrect reason</td><td>1</td></tr>
<tr><td>Incorrect answer, correct reason or correct answer, incorrect reason</td><td>2</td></tr>
<tr><td>Correct answer, correct reason</td><td>3</td></tr>
<tr><td rowspan="4">2</td><td rowspan="4">Telescope</td><td rowspan="4">2. Perhatikan gambar dibawah ini!


Gambar. Teleskop
Pada saat Bulan purnama, Andi mengamati peristiwa tersebut dengan sebuah teleskop. Pada sebuah teleskop terdiri dari dua jenis lensa yaitu lensa objektif dan lensa okuler. Andai mempunyai 3 lensa objektif dan 3 lensa okuler yang mempunyai jarak fokus yang berbeda-beda seperti pada tabel di bawah ini:
Tabel. Jenis Lensa dan Jarak Fokus Lensa
<table><tr><th>Jenis Lensa</th><th>Jarak Fokus Lensa</th></tr><tr><td>Lensa Okuler A</td><td>2 cm</td></tr><tr><td>Lensa Okuler B</td><td>4 cm</td></tr><tr><td>Lensa Okuler C</td><td>6 cm</td></tr><tr><td>Lensa Objektif A</td><td>20 cm</td></tr><tr><td>Lensa Objektif B</td><td>40 cm</td></tr><tr><td>Lensa Objektif C</td><td>60 cm</td></tr></table>Jika mata Andi tidak berakomodasi, manakah dua lensa yang dipilih oleh Anda untuk menghasilkan bayangan terbesar? Jelaskan!</td><td>The student did not answer</td><td>0</td><td rowspan="4">6.7</td><td rowspan="4">20</td></tr>
<tr><td>Incorrect lens combination, incorrect reason</td><td>1</td></tr>
<tr><td>Correct lens combination, incorrect reason or incorrect lens combination, correct reason</td><td>2</td></tr>
<tr><td>Correct lens combination, correct reason</td><td>3</td></tr>
<tr><td rowspan="4">3</td><td rowspan="4">Mikroskop</td><td rowspan="4">3. Bacalah paragraf berikut ini!


Paragraf 1
Mikroskop memiliki struktur yang berbeda-beda, namun pada dasarnya memiliki elemen utama seperti lensa objek dan lensa okuler. Lensa objek berfungsi untuk membiaskan cahaya yang melewati objek, sementara lensa okuler berguna untuk memfokuskan gambar ke mata pengamat. Benda mikroskop berfungsi sebagai wadah untuk menempatkan objek yang akan diamati. Fungsinya sendiri sangat penting dalam meneliti benda-benda yang sangat kecil seperti virus, sel, dan bakteri. (Westheimer, 1981).
Paragraf 2
Cara penggunaan mikroskop dapat dilakukan dengan beberapa langkah sederhana. Pertama, nyalakan sumber cahaya yang terdapat pada mikroskop. Kemudian, letakkan objek yang akan diamati pada benda mikroskop dan atur fokus lensa dengan menggunakan sekrum fokus yang terdapat pada mikroskop. Terakhir, perbesar objek hingga sesuai dengan kebutuhan dengan mengatur lensa objek dan lensa okuler. Hal ini sangat penting agar pengamatan pada objek yang sangat kecil dapat dilakukan dengan akurat. (Arrozi, 2019)
Berdasarkan kedua paragraf diatas, bagaimana pendapatmu mengenai mikroskop?</td><td>The student did not answer</td><td>1</td><td rowspan="4">6.7</td><td rowspan="4">20</td></tr>
<tr><td>The student mentions the similarities or differences between two microscopes without a conclusion</td><td>2</td></tr>
<tr><td>The student mentions the similarities and differences between two microscopes with a conclusion</td><td>3</td></tr>
<tr><td>The student mentions the similarities and differences between two microscopes with a correct conclusion</td><td>4</td></tr>
</table>

No	Topics		Questions	Assesment scoring	Count	Point	Score
4	**Kamera**	4.	Perhatikan kedua gambar berikut ini!    *Kamera merupakan alat optik yang diciptakan oleh manusia dengan mengambil prinsip kerja pada mata manusia. Beberapa bagian pada kamera memiliki fungsi yang sama seperti pada struktur pada mata manusia. Kempokanlah bagian-bagian kamera dengan struktur pada mata berdasarkan fungsi dan kemiripannya! Mengapa bagian pada kamera memiliki fungsi yang sama pada struktur mata?*	The student did not answer	**0**	**6.7**	**20**
				The student can mention the parts of the lens and camera	**1**		
				The student can mention the parts of the lens and camera as well as their similarities	**2**		
				The student can mention the parts of the lens and camera as well as their similarities and the functions of the parts of the camera and the eye	**3**		
5	**Proyek Siswa** *Focusing questions*	*5*	*Bagaimana anda merancang sebuah proyektor menggunakan kaca pembesar dan sebuah kardus? Apa yang harus anda lakukan agar gambar bayangan yang dihasilkan oleh proyektor tersebut dapat terlihat jelas?*	The student did not answer	**0**	**6.7**	**20**
				The student can write the steps for making a projector using a magnifying glass	**1**		
				The student can write the steps for making a projector using a magnifying glass. The student can provide strategies to ensure the projector's image quality is clear	**2**		
				The student can write the steps for making a projector using a magnifying glass. The student can provide strategies to ensure the projector's image quality is clear. The student can provide a conclusion and reason why they designed a handmade projector.	**3**		
Total score							**100**