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Article

STEAM-Design Process with Telescope Project to Foster Students's Attitude Toward Science

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ABSTRACT

Attitude Toward Science in the PISA global ranking shows a low-average. This study analyzed the effect of STEAM-Design Process on students' attitude toward science in the topic of optical instruments. Quantitative research method alongside a quasi-experimental design was utilized in this study. The experimental class used the STEAM-Design Process whereas the control group used conventional learning. The sample for this study were 8th-grade students from a public school in Tasikmalaya Regency, Indonesia. The experimental group consisted of 38 students, while the control group consisted of 30 students. Students ages ranged from 13-14 years old. The data obtained in this study used 60 statements form a questionnaire with two open-ended questions. The findings revealed a significant difference in attitude toward science between the experiment and control class. The N-Gain score in the experiment class is 0.32 and control class 0.12, which is described as medium and low improvement. Based on this research, teaching through STEAM- Design Process is effective approach that can be significantly improve attitude toward science. Educators should consider integrating this model more broadly in secondary science curricula. It is recommended to explore the long-term effects and explore ways to better support the emotional dimensions of student attitudes.

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INTRODUCTION

Student's attitude toward science is the way students respond to science lessons. Generally, there are two types of attitudes toward science: negative and positive. Students' positive attitudes toward learning are defined by being more diligent in learning to get satisfying results (Rijal & Bachtiar, 2015; Astalini et al., 2019). Students' positive attitudes towards science, technology, engineering, and mathematics disciplines will help them acquire 21st-century skills, these skills are not only confined to academic settings but are expected to be integrated into individual's daily lives, guiding their decision-making and

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problem solving in various domains (Uzel & Bilici, 2021; Demir, 2015; Ernst & Haynie, 2010; Wells, 2008; Purnama et al., 2023). Furthermore, to improve their performance on international examinations like PISA and TIMSS. Indonesian students' science performance has often been below the average (OECD, 2014). The slow progress in science and technology also hinders educational development in Indonesia. In another report, a change in the PISA results between 2006 and 2015 suggested that Indonesian students were less engaged in science activities and less interested in learning about science.

Attitude toward science presented as the important parts to produce students who able think scientifically. One of the functions and objectives of science learning is that students gain experience through the application of scientific methods through experiments so students can be trained in scientific attitude (Istikomah, Hendratto & Bambang, 2010; Astalini et al, 2019) The teacher can tell how each student reacts to science instruction by observing their attitude, which can indicate whether they accept or reject it. The term "attitude" in education more frequently describes an individual's academic performance (Ali, Iqbal & Saeed Akhtar, 2013; Astalini et al., 2019). Attitudes toward science are important since they have a strong impact on students' performance and achievements (Astalini et al., 2019).

Nowadays, many students lose interest in studying science (Glynn et al., 2011; Kiah-Ju Ong, et al, 2019). Physics is a field of science that studies physical natural phenomena through observation, experimentations, and theory. (Prima et al., 2018; Afriani et al., 2019). Physics learning includes developing students' knowledge, understanding, and analytical skills regarding the environment and surroundings (Azizah et al., 2015; Hamid, 2021). They are required to address complex problems by applying their knowledge and understanding to everyday situations (Nabilah & Jumadi, 2022), able to utilize scientific methods to validate the physics concepts obtained from the theory (Diana et al., 2019).

Students' learning outcomes for physics subjects remain quite poor. When working on physics problems presented by the teacher, students frequently apply mathematical equations without analyzing, guessing the formula or recalling examples of previously completed questions to work on other problems. Students have difficulty dealing with complex problems. Students can solve easy quantitative problems but not more difficult one (Redish, 2005; Surjawanto et al., 2014). Most students do not have a positive attitude towards learning physics (Prima et al., 2018; Afriani et al., 2019). Students' attitudes toward a specific academic domain were reflected by their subject-spesific motivation (Smart, 2014; Kaisan et al., 2024)

Real-world problems cannot be easily addressed through conventional education. Conventional education emphasizes the development of students' knowledge, but in the 21st century, students require skills-based education to tackle real-world problems. As a result, deciding on an educational strategy or approach is essential (Kim et al., 2019; Suganda et al., 2021). New ways are needed to improve science and make science learning more engaging (Condradty & Bogner, 2019). STEAM-based learning is one technique that has the ability to meet the demands of 21 st century learning (Baek et al., 2011; Yakman, 2008; Utomo et al., 2020). These components of the five fields of science in the STEAM approach will make learning physics more attractive to students and help students understand the elements of science, technology, and engineering more straightforwardly and enjoyably supported by art and mathematics content. Learning science, including physics, is more meaningful when students experience or observe directly rather than just learning facts, concepts, principles, or theories (Ausubel, 1968; Wardani & Winarno, 2017). Students' conceptual understanding can be improved by learning by doing, where students apply their knowledge in practical, real-world scenarios (Yu, 2024). Educators should provide a teaching and learning activity that attracts students & interest (Tural, G.,2015; Wardani & amp; Winarno, 2017).

STEAM education in line with the 2013 curriculum. Therefore, its implementation in Indonesian schools equips students to gain 21st-century skills, such as critical thinking, creativity, innovation, problem-solving, and collaborative decisions (Pasani & amp; Amelia, 2021). The 2013 curriculum, designed for thematically integrated learning, aligns well with the principles of STEAM-based education, particularly at elementary and junior high school levels where subjects are already thematically integrated (Saddhono et al., 2020). STEAM allows for the integration of art-based and creative curriculum aspects to enhance learning and bring real-life experiences into the classroom. This could include writing and telling stories, poetry, role-playing, and incorporating design into solutions, values/ethical discussions, and so on. STEAM describe the fundamental principles of the technology used to develop models and prototypes before constructing or deconstructing (Arapaci et al., 2023). Students are more likely to be motivated if the ideas and difficulties they face in the course are relevant to the world around them (Thuneberg et al., 2018; Arapaci et al., 2023).

There have been several research investigates the impact of STEAM-based teaching activities on students' attitude in Turkey (Ozkan, 2022), The impact of STEAM-based activities on students & attitudes toward cooperative working skills and career choice in Elementary School (Konkus & Topaskal, 2022), Tanti et al. (2021) analyse attitude toward science using mixed methods and STEAM activity on students' attitude toward science in Elementary School in Korea (Kong & Ji, 2014). Other quantitative research method used in various studies, such as Wu et al. (2022) investigated STEAM education through attitude, motivation and cognitive load incorporating the bloom taxonomy. Huang (2020) examines the impact of STEAM education on students' learning attitudes and outcome. Examine students' attitudes toward STEAM using a 3D design projects (Mou, 2023). However, this study uses a quasi-experimental involving secondary school students, implementing a STEAM-Design Process in the context of optical instruments topic, and analyzing six distinct attitude sub-domains. The research contribution is that it empirically demonstrates how a structured STEAM-Design Process can significantly improve secondary students' attitudes toward science in a domain-specific topic, and it identifies which attitudinal dimensions (e.g., usefulness, enjoyableness, self-efficiency, etc) are most responsive to change.

METHODS

Research Method

Quantitative research method used in this study. According to Fraenkel, Wallen, and Hyun (2013), quantitative research examines potential relationships between variables and explains why those relationships exist. For research design, used a quasi-experimental model utilizing nonequivalent (Pretets and Postets) group design. This method is particularly appropriate for this study because fully randomized student assignment is not feasible in a real classroom setting. In educational environments like secondary school, existing intact classes are more practical to use, and nonrandom group assignment still allows for meaningful comparison while preserving ecological validity. By administering a pretest and posttest, the design helps control for baseline differences between two groups, thereby enhancing improving the internal validity of the causal conclusion. This approach enables the researcher to closely assess the impact of the STEAM-design Process on students' attitude toward science in a way that reflects genuine classroom conditions. Studies using this design were assigned as experimental and control group. Where there is a treatment group (experimental group) is given a pretest, receives a treatment, and then given a post-test. However, ath the same time, anonequivalent control group is given a pre-test, does not receive the treatment, and the is given a post-test. This reseach design is to know wether they improve more than participants who do not receive the treatment. The research design displayed in Table 1.

Table 1. Nonequivalent Pretest-Posttest Control Group Design

Group	Pre-Test (O_1)	Treatment	Post--Test (O_2)
Experiment Class	O_1	X	O_2
Control Class	O_1	-	O_2

Source: (Creswell & Creswell, 2018)

Note:
O_1 are pre-test that students' skill in scientific literacy and attitude toward science
X is the treatment, which is the STEAM-Design Process
(-) is the treatment, which is the conventional learning
O_2 are post-tests that students' skill in scientific literacy and attitude toward science
(-) students are subjects that are not a random sample

Therefore, it is possible to investigate and compare the effect of STEAM on students' scientific skills and students' attitudes toward science pretest and after the concept given the treatment of the final post-test from two groups.

Participants

The participants of this research are 68 students from 8th-grade students from one of the public schools that use Kurikulum 2013 in Kabupaten Tasikmalaya, West Java, Indonesia. The students' ages ranged from 14 to 15 years old and they had not studied Optical Instruments before. The sampling technique used in this study is convenience technique. The convenience technique is used because there is a group of individuals who (conveniently) are available for study (Fraenkel et al., 2013; Wandari et al., 2018). The distribution of the sample was charactherozed by gender, as highlited in the breakdown provided in Table 2.

Table 2. Detail of Research Sample Based on Gender

Gender	Experiment Class		Control Class	
	Frequency	Percentage	Frequency	Percentage
Male	12	31.6%	7	23.3%
Female	26	68.4%	23	76.7%
Total	38	100%	30	100%

Data Collection Tools

A questionaire with 60 question for students' attitude toward science test adopted form Kennedy et al. (2016) distributed using Google Froms, but the control class used paper-based because the class was not conducive to using phones during learning. Kennedy et al. (2016) gathered five common themes from this research that are particularly relevant to students developing a science-related mindset. The following specified factors serve as the basis for determining the aspects of student attitudes regarding the science disciplines they study are enjoyableness, difficulty, self-efficacy, relevance for everyday life, usefulness of career, and intention to enroll. Each scale consist of several items as presented in Table 3.

Table 3. Blueprint of Questionnaire Attitude Toward Science Each Scale

Scale	Number of Statement		Total
	Positive	Negative	
Enjoyableness	7	7	14
Self-Efficacy	8	1	9
Relevance for daily live	6	5	11
Usefulness of career	5	5	10
Intention to enroll	3	3	6
	Total		60

Data was collected from May 15 – June 5, 2024. With six meetings, both experimental and control classes have 2 meetings with 2 lesson hours (2x40 minutes), then 4 meetings with

3 lesson hours (3x40 minutes). The comprehensive implementation activities in the classroom Figure 1.

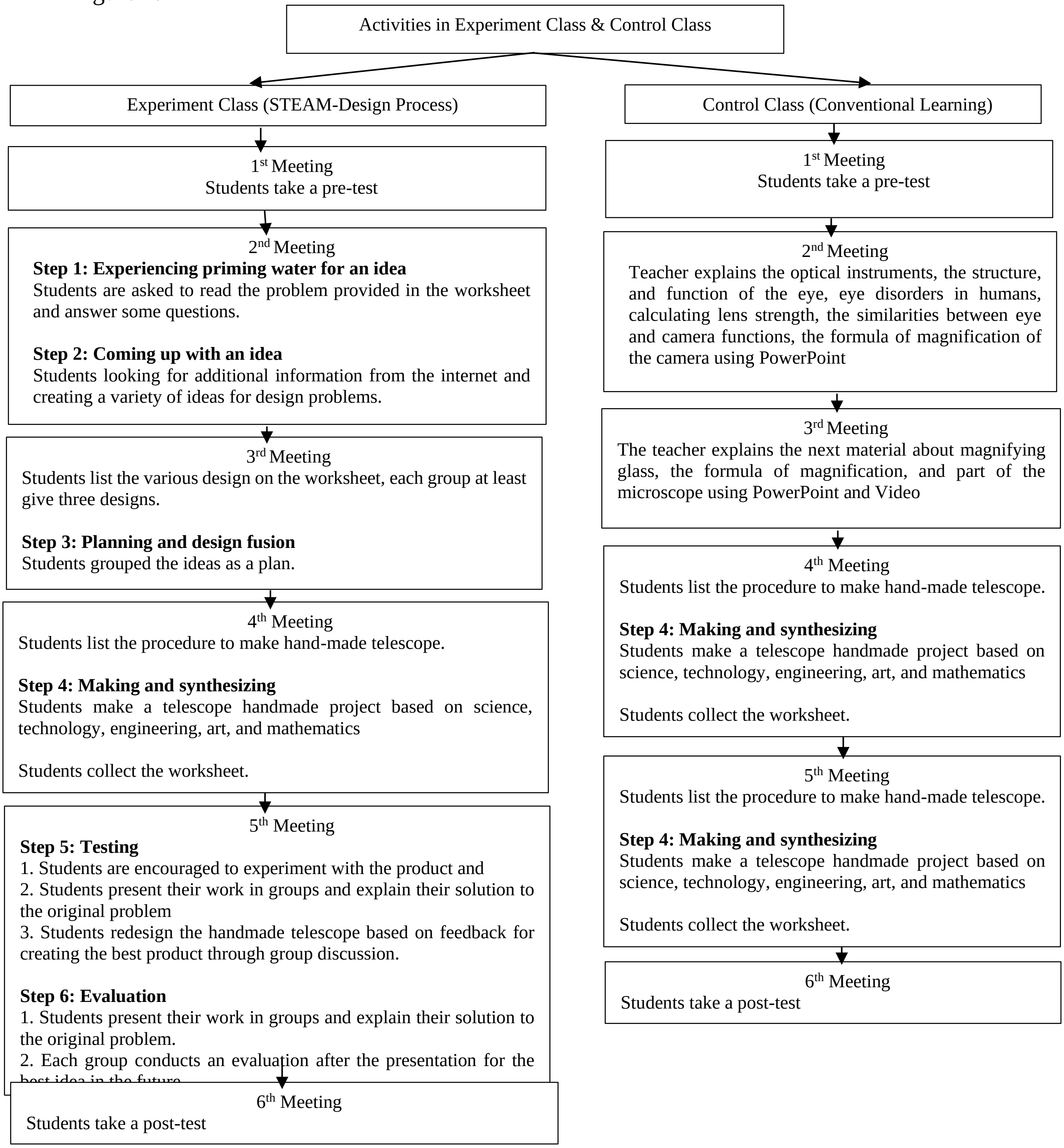

Figure 1. Activities in Control Class and Experiment Class

Data Analysis

A likert scale will measure the Attitude Toward Science Questionnaire in this research. For a statement with a positive statement, students get a score of one if they answer strongly disagree, a score of two disagree, a score of three neutral, a score of four agree, and a score of five strongly agree. Meanwhile, for points for negative statements, students get a score of five if the answer strongly disagrees, a score of four disagree, a score of three for neutral, a score of two agree, and a score of one strongly agree**.**

Since the instrument is adapted from Kennedy et al. (2016), the Attitude Toward Science Questionnaire has already been through validation and reliability. For the single-item measures used in the SSAS to be considered valid, they should ideally have a reliability estimate greater than 0.70 for individual-level data and 0.80 for group-level data. Table 4. shows the reliability of the final SSAS instrument.

Table 4. Reliabilities for the final Attitudes Toward Science Questionnaire

Sub-scale	Reliability
Enjoyableness	0.94
Difficulty	0.90
Self-Efficacy	0.89
Usefulness	0.90
Relevance	0.90
Intention to enroll	0.97

(Kennedy et al., 2016)

After collecting the data, the researcher converted it to percentages using Ms. Excel. Then, the score converted will then be statistically measured. Using SPSS, prerequisite tests such as normality and homogeneity are initially performed to see if the data can be used for parametric or nonparametric test. Accordingly, the Mann- Whitney U Test tis used determine if there is a significant difference between the experiment and control groups in the hypothesis test. To determine whether each class pre-test and post-test values increased, the gain score represents the difference between the pre-test and post-test scores, with the aim to assess students' attitudes toward science. This statistic displayed the outcome after an intervention, indicating the effectiveness of the implemented treatment on students. The N-Gain score is used to describe the results of the questionnaire. Then N-Gain (Normalized Gain) test was carried out using Ms. Excel. The N-Gain test will also show a comparison of the improvement between the experimental class and the control class. Also, it is examined to categorize the research outcome according to established benchmarks, elucidating the extent of enhancement stemming from the treatment given. The effectiveness criteria interpreted from N-Gain are described in Table 5.

Table 5. N-Gain Score Interpretation

N-Gain Score	Category
$0.70 \leq n \leq 1.00$	High
$0.30 \leq n \leq 0.70$	Middle
$0.00 \leq n \leq 0.30$	Low

The formula employed to compute the actual normalized gain is presented as follows:

$$< g >= \frac{S_f - S_i}{S_{max} - S_i}$$

Were,

$<g>$ = Average Normalized-Gain Score

S_f= Score of post-test

S_i = Score of pre-test

S_{max}= Total score Source: (Hake,1998)

RESULTS AND DISCUSSION

The Effect of STEAM-Design Process on Students' Attitude Toward Science

As the first step in statistically analyzing the data, the average, maximum, and minimum scores were measured to give brief information about the data, as shown in Table 6.

Table 6. Recapitulation of Students' Attitude Toward Science Questionnaire

Component	Pre-Test		Post-Test	
	Experiment	Control	Experiment	Control
N	38	30	38	30
Average Score	64.6%	62.4%	75.8%	67.4%
Maximum Score	54.3%	42%	62.3%	67.4%
Minimum Score	82%	81.7%	89%	82.3%

Table 6 reveals that the experiment class's average pre-test score was 64.6%, which increased by 11.2% in the post-test to 74.08%. In the control class, the average increase was 5 from pre-test 62.4% to post-test 67.4%. For the experiment class, the maximum scores for the pre-test and post-test are 82% and 89%, respectively, whereas the minimum scores are 54.3% and 67.4%. Moreover, for the control class's maximum score of the pre-test and post-test is 81.7% and 82.3%, respectively, while for the pre-test and post-test it is 62.4% and 67.4% as the minimum score. Figure 2 shows the average difference between the experiment and control classes in the pre-test and post-test.

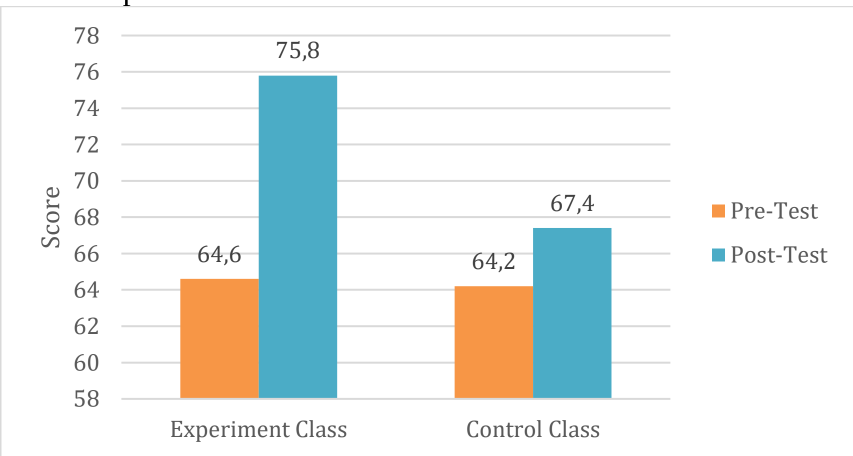

Figure 2. The Comparison of Attitude Toward Science Average Score between Experiment and Control Class.

From figure 2, we can see the development of pre-test and post-test. However, the score change in the experiment class is greater than in the control class. We must calculate the N-Gain score to determine whether the development is good. However, before calculating N-Gain, we must do a normality test and homogeneity test within the pre-test and post-test, which were measured first as the prerequisite test of the hypothesis test. The result of the normality test using Shapiro-Wilk Test in the pre-test and post-test between the experiment and control classes is shown in Table 7.

Table 7. Normality Test Result of Students' Attitude Toward Science Questionnaire

Component	Pre-Test		Post-Test	
	Experiment	Control	Experiment	Control
Signification (Sig. > 0.05)	0.015	0.032	0.010	0.021

Component	Pre-Test		Post-Test	
	Experiment	Control	Experiment	Control
Information	Not Normally distributed	Not Normally Distributed	Not Normally Distributed	Not Normally Distributed

From Table 7, the normality test values of the pretest and post-test of both experiment and control classes were not normally distributed because the significant value was less than 0.05, the values significant pretest and post-test experiment class 0.015 and 0.010, in the control class pre-test and post-test with significant 0.032 and 0,021 The next prerequisite test is the homogeneity test using the Levene Test which is shown in Table 8.

Table 8. Homogeneity Test Result of Students' Attitude Toward Science

Component	Pre-Test		Post-Test	
	Experiment	Control	Experiment	Control
	Levene Test		Levene Test	
Signification (Sig. > 0.05)	0.811		0.006	
Information	Data Homogeny		Data Not Homogeny	

It is shown in Table 8, that the data in the post-test between the experiment and control classes is not homogenous. The homogeneity score for the data is 0.006 with α < 0.05. However, the pre-test data between the experiment and control classes is 0.811, with α > 0.05, indicating that the data is homogenous. Based on the normality and homogeneity test result, the hypothesis may be tested using the non-parametric test. Because the data is not normally distributed and there is heterogeneity on the post test results between the experiment and control groups. So, the Mann-Whitney U Test will be used for the non-parametric test since the prerequisite test does not qualify as a parametric test, as shown in Table 9.

Table 9. Mann-Whitney U Test

Component	Pre-Test		Post-Test	
	Experiment Class	Control Class	Experiment Class	Control Class
	Levene Test		Levene Test	
Signification (Sig. < 0.05)	0.240		0.000	
Information	Ha rejected		Ha accepted	
Conclusion	There is no significant difference		There is a significant difference	

Based on Table 9, revealed for the pre-test the H_1 is rejected and H_1 is accepted with the Mann-Whitney U Test score of 0.000, which is lower the significant value α < 0.05, indicating a significant difference in students' attitudes toward science objectives. Likewise, the post-test with 0.000, which is lower than the significant value α < 0.05, indicating a significant difference between the experiment and control classes after giving the treatment. Furthermore, the N-Gain score of the comparison between the experiment and control classes was good, as shown in Figure 3.

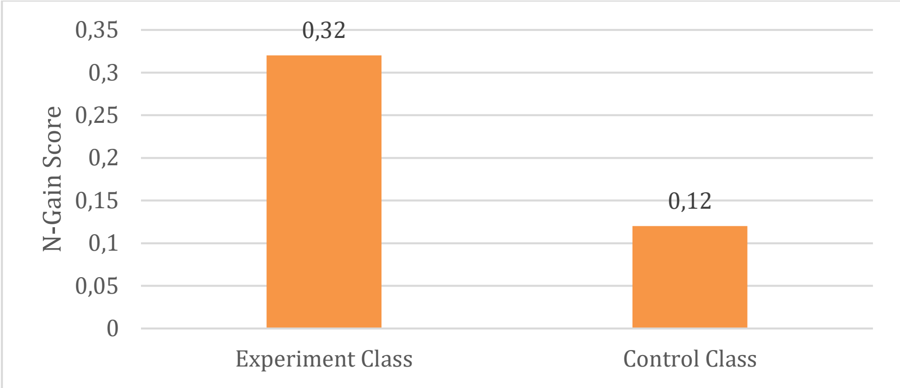

Figure 3. Comparison of Attitude Toward Science N-Gain Score between Experiment Class and Control Class

According to Figure 3, the N-Gain score between the experiment and control classes is significantly different, with the experiment class being higher than the control class. As we can see, the N-Gain score in the experiment class is 0.32, indicating a medium improvement, while in the control class, it is 0.12, indicating a low improvement. However, the improvement of the N-Gain score in the experiment class may be affected based on the implementation of the STEAM design process. Figure 3 show some stages of STEAM-Design Process and result project for this study making telescope handmade at experiment class.

(a) (b)

Figure 4. (a) One stages of STEAM-Design Process (Planning and Design Fusion) and (b) The result of making telescope handmade

Meanwhile in control class students do poster about optical instruments like shown in the Figure 5.

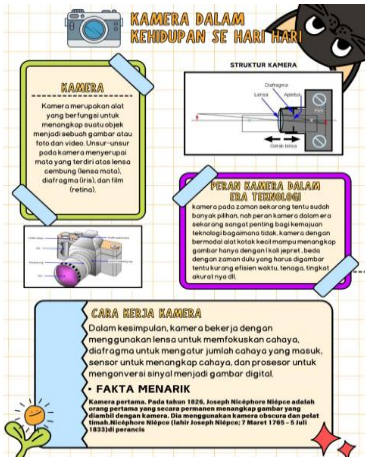

Figure 5. Poster Optical Instruments about Camera made by one group at control class

Both science and arts require observation for proper interpretation of observed phenomena, it has, become critical to improve learners' active learning by creating an open learning environment in which students can interact with the content being taught while using art as a teaching tool (Najami et al., 2019). The arts continue to be a medium for ideation which involves the conceptualising, analysing, and exchanging of ideas (Keane & Keane, 2017). Therefore, applying the arts, becomes crucial because it can enable learners to build scientific communication skills while addressing their effective learning outcomes (De Beer et al., 2018). The arts will provide inspiration and novelty opportunities for cognitive and social development. It will also boost creativity, reduce stress, and make science classes more enjoyable (Sousa & Pilecki, 2013). The arts are a set of abilities and mental processes that extend across all domains of human endeavour (Sousa & Pilecki, 2013). They allow learners build their methods of knowing and interpreting the world (Keane & Keane, 2017). The arts also highlight empathy, which enormously impact on learners' motivation and desire to address scientific challenges (Bush & Cook, 2019). Integrating of arts in science education lends an effective component of the complicated STEM concepts and challenges. This makes the learning of content in science more accessible (Smith & Pare, 2016) and more engaging (Bush & Cook, 2019), potentially reinforcing learners' positive attitudes toward science. The STEAM educational approach potential to impact attitudes by reducing practical barriers to knowledge (Marmon, 2019).

Many studies have investigated the relationship between attitudes toward science and STEAM. According to Karjanto (2017), a significant difference in students' attitudes toward science after participating in an activity, career interests and attitudes related to science improved significantly (Ong et al., 2019). Additionally, STEAM activities have a significantly wider effect on improving positive attitudes (Akçay et al., 2020). The following are some of the ways that STEAM education influences students' attitudes toward science learning (Wu et al., 2022): STEAM projects are possible to increase students' interest (Mou, 2023), STEAM education has a remarkably positive attitude on learning outcome (Huang, 2020), A positive attitude is provided by the STEAM teaching methodology (Ozkan, 2022). Align with the study results revealed a significant distinction in students' attitudes toward science within the experiment and control classes. Since the STEAM-Design process is applied in the experiment class, it receives a more excellent N-Gain score than the control class.

The Effect of STEAM-Design Process on Students' Attitude Toward Science on Each Subscale

According to Kennedy et al. (2016), there are six subscales of creativity: enjoyableness, difficulty, self-efficacy, relevance, usefulness, and intention to enroll. All of the subscales will be analyzed statistically one by one. The recapitulation score of students' attitudes toward science on each subscale is shown in Table 10.

Table 10. The Recapitulation Score of Students' Attitudes Toward Science on Each Subscale

Class	Component	Attitude Toward Science Scale											
		Enjoyableness		Difficulty		Self Efficacy		Relevance		Usefulness		Intention to enroll	
		Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
Ex ne	X	35.8	38.8	59.4	72.7	61.0	74.7	66.7	76.5	64	74.8	59.9	72.8

Class	**Component**	**Attitude Toward Science Scale**											
		Enjoyableness		**Difficulty**		**Self Efficacy**		**Relevance**		**Usefulness**		**Intention to enroll**	
		Pre-Test	**Post-Test**	**Pre-Test**	**Post-Test**	**Pre-Test**	**Post-Test**	**Pre-Test**	**Post-Test**	**Pre-Test**	**Post-Test**	**Pre-Test**	**Post-Test**
	Gain	3		13.3		13.7		9.8		10.8		12.9	
	N-Gain	0.05		0.33		0.20		0.29		0.30		0.32	
	N-Gain Category	Low		Medium		Low		Low		Low		Medium	
	Wilxocon Test	0.000		0.000		0.000		0.000		0.000		0.000	
	Information	Significant		Significant		Significant		Significant		Significant		Significant	
Control Class	X	32.8	35.1	58.8	63.3	59.7	66.7	63.2	69.6	62.8	66.9	60.6	65.4
	Gain	2.3		4.5		7		6.4		4.1		4.8	
	N-Gain	0.03		0.11		0.17		0.17		0.11		0.10	
	N-Gain Category	Low		Low		Low		Low		Low		Low	
	Wilxocon Test	0.059		0.004		0.001		0.001		0.043		0.017	
	Information	No Significant		Significant		Significant		Significant		Significant		Significant	
Mann-Whitney		0.006	0.001	0.550	0.000	0.555	0.001	0.224	0.003	0.511	0.000	0.502	0.001
Information		Significant	Significant	No Significant	Significant	No Significant	Significant	No Significant	Significant	No Significant	Significant	No Significant	Significant

From Table 10, the highest gain is obtained by difficulty and intention to enroll with gain values of 13.3 and 12.9, which have only a 0.4 point, difference with a medium N-gain category with values of 0.33 and 0.32. The other four categories are enjoyability, self-efficacy, relevance, and usefulness, with gain values of 3, 13.7, 9.8, and 10.8 in the low N-Gain category. The difference between the average scores pre-test and post-test will influence the N-Gain score. The remaining four categories have N-Gain score of 0.05, 0.20, 0.29, and 0.30 in sequence from these results. Then, the Wilcoxon test was used to compute the pre-test and post-test findings for each sub-scale. All sub-scales difference significantly between the pre-test and post-test, even though the fact that average score of the pre-test and post-test in the experimental class showed a slight increase. In the control class, the increase in gain score was in the range of 2.3-7 points, all sub-scale attitudes towards science showed a low increase. Based on the Wilcoxon test results, there is one category declared insignificant between the pre-test and post-test, enjoyability, since the rise between the pre-test and post-test is minimal, only 2.3 points. For more clarity, let us see the comparison between the experimental and controlclasses on each sub-scale in Figure 6.

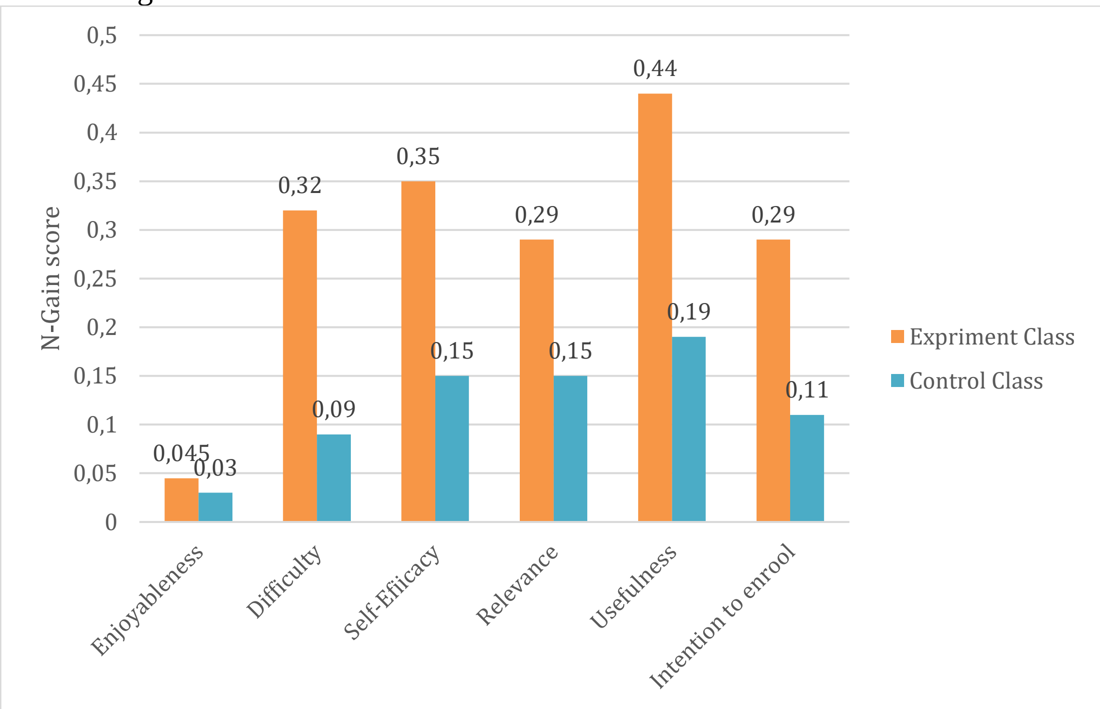

Figure 6. Comparison N-Gain Score between Experiment Class and Control Class in Each Subscale

Based on Figure 6, the N-Gain score of Enjoyableness shows the lowest scores in both the experiment and control classes. The difference in the N-Gain score is only 0.015, which is more significant than the experiment class score. This is also proven by the Mann-Whitney U Test, which states that there is no significant difference in the post-test score in the control class. The statement included in the sub-scale enjoyableness is appears in Figure 7.

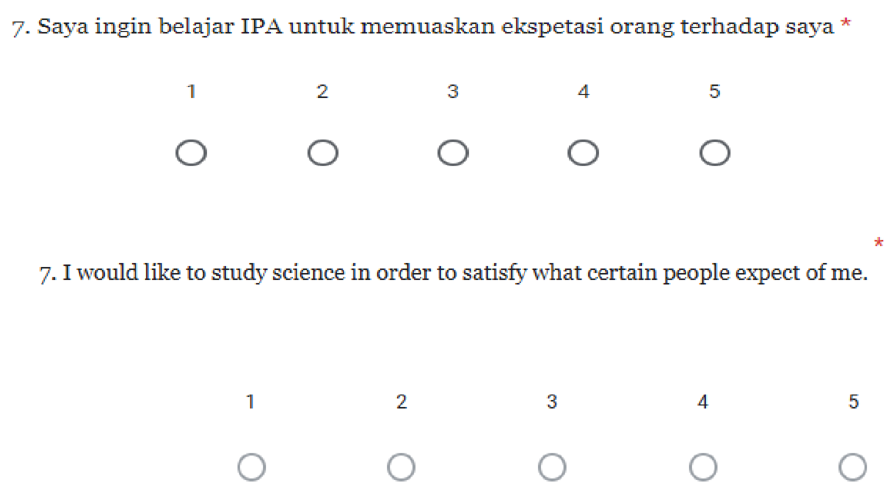

Figure 7. Statement number 7

Statement number 7 is the lowest average score in enjoyableness in the control class of attitudes toward science questionnaire. Meeting others' expectations influences students' enjoyment of learning science by enhancing motivation, addressing gaps, and improving academic performance through knowledge sharing and positive attitudes in a supportive learning environment (Gara, 2023). However, it can also cause middle school students to experience more stress and develop negative attitudes toward science, affecting their interests, abilities, and attitudes toward science (Zacharia & Barton, 2004).

Many factors have been found to influence students' attitudes toward science, including gender, social background, teachers, curriculum, and learning environments (Osborne et al., 2003; Kapici et al., 2020), learning environment (Hofstein & Lunetta, 2004; Lazarowitz & Tamir, 1994, Kapici, Akcay and Jong, 2020), Haladyna & Shaughnessy (1982) stated that learning environments play essential in influencing students' attitudes toward science (Kapici et al., 2020). The science laboratory is a major learning environment used in science teaching that can encourage students to develop a positive attitude toward science (Chen et al., 2014; Kapici et al., 2020).

Science learning enjoyment is defined as the extent to which science classes are generally enjoyed (Wang & Berlin, 2010; Membiela et al., 2021). Because learning enjoyment affects a student's attitude toward an object, so it is a crucial component of the educational process for students (Kurniawan et al., 2019). Students comfortable and enjoying their scientific classes will show this (Astalini et al., 2019). Fostering interest in science learning without enjoyment might not produce real interest, wherein students respect the scientific knowledge and abilities they learn (Jack & Lin, 2018). According to Nursa'adah's (2014) research, there is an interaction effect on science learning outcomes between student attitude toward science learning and learning method. Students' attitudes toward learning are influenced by their enjoyment and interest in science classes (Tan, 2023). Emotional variables (a sense of joy in science lessons) are crucial aspects of science learning. The connection between emotional factors and science learning participation in previous research. Sinatra et al. (2014) state that emotions influence cognitive functions, motivation, engagement, and achievement results, which mediate scientific learning (Membiela et al., 2021). Success in science education can also foster enjoyment (Perera, 2014; Membiela et al., 2021), and student-centered learning is thought to increase enjoyment in the learning process (Cho et al., 2021; Membiela et al., 2023). However, the STEAM design process created students-centered science learning activities in this research experiment class. In contrast, the control class engages conventional learning and teacher-centered learning. Science Teacher-centered science instruction may make it harder for students to understand the material (Fahrezi et al., 2020; Santosa et al., 2024).

Apart from using questionnaire statements, this research also uses open-ended questions that reinforce the results obtained. There are two open-ended questions. Number one is why students like science, as shown in Table 11 for the experiment and control classes.

Table 11. Reason Students Like Science

Experiment Class		**Control Class**	
Reason	**Percentage (%)**	**Reason**	**Percentage (%)**
Enjoys learning science	47.4	Get to learn new things	26.7
Laboratory practical	18.4	Challenging	20.0
Likes to do calculations	10.5	Teacher explains clearly	13.3
Did not give a reason	7.9	Laboratory practical	6.7

Experiment Class		Control Class	
Reason	**Percentage (%)**	**Reason**	**Percentage (%)**
Real-life connection	7.9	Easy to understand	6.7
Likes the content learnt*	5.3	Enjoys learning science	6.6
Teacher explains clearly	5.3	Aspirations to be a doctor	3.3
Neutral	5.3	Dislikes science	3.3
		Real-life connection	3.3
		Likes doing the practice questions & summaries	3.3
		Likes to do calculations	3.3
		Real-life connection	3.3
Total	100	**Total**	100

Table 11 shows the most common reasons students like science in experiment class. There are eight reasons; the three most common reasons are enjoys learning science, laboratory practical, and likes to do calculations. This result supports the previous diagram's findings, which demonstrated a significant difference in enjoyableness between the experimentatal and control clasees, despite the fact that the N-Gain difference was only 0.015 points. As previously stated, the classroom environment and learning activities employed in science teaching can enable students to acquire a positive attitude toward science, as can using the arts to boost learners' confidence, attitudes and enthusiasm for science. This suggests that the STEAM approach affects on students' enjoyment when learning science. The three most common reasons in control class are learning new things, being challenged, and having the teacher explain things clearly. In the control class, students were asked to make a poster containing optical instruments. Previously, the students had never created a product such as poster as a result of their studies. They found this session difficult because it was new to them, especially since they had to construct a poster using Canva. Because of the use of media, they found challenging to work in groups for the assignment. However, it did not damper the students' enthusiasm in designing posters with Canva. The second open-ended question discusses why students do not like science, Table 12 contains why students do not like studying science in experiment and control classes.

Table 12. Reason Students Did Not Like Science

Experiment Class		Control Class	
Reason	**Percentage (%)**	**Reason**	**Percentage (%)**
Challenging to understand new equations	23.7	None because they enjoy learning science	53.3
Calculation based-question	23.7	Difficult to understand	20
Difficult to understand	23.7		
None because they like science	10.5	Calculation-based questions	10
Do not like the taught materials	7.9	Makes them feel dizzy	3.3

Experiment Class		Control Class	
Reason	**Percentage (%)**	**Reason**	**Percentage (%)**
		Group assignments	3.3
Incomplete explanations	2.6	Not enough time given to do the assignments	3.3
Too much material is explained at one time	2.6	There is too much to learn	3.3
Having to draw diagrams	2.6	Having to summarize the material	3.3
Makes them feel demotivated	2.6		
Total	100	**Total**	100

Based on Table 12, in the experiment class, there are ten reasons why students do not like science three of the most common reason is challenging to understand new equations, calculation based-question, difficult to understand (each at 23.7%) and the second and third common reason is none because they like science, do not like taught materials (physics/biology/chemistry). This was because of to time constraints in teaching the content, which resulted in students less than optimal understanding of the formulas. Likewise, in the control class, the most common reason is none because they enjoy learning science with the highest percentages 53.3%, then difficult to understand with percentage 20%, and last is calculation-based questions with 10% percentage. As stated before, students enjoy the science class because they get learn new things and teacher explain the content clearly.

The study's findings indicate related attitudes toward science and the STEAM approach. This study aligns with a previous study of STEAM potentially reinforce learners' positive attitudes toward science (Marmon, 2019). STEAM makes the learning content in science more accessible and engaging. Integrating arts in science education leads to the effective component of the complicated STEM concepts and challenges to improve learners' confidence, attitudes, and interest in science. This result can be obtained by implementing the experiment class's STEAM-Design Process. The previous research from Han and Shim (2019) stated that the incorporation of EDP into STEAM activity helped increase students' interest, positive attitude, and understanding of occupations in natural sciences and engineering. Using integrated science teaching materials based on science literacy has significantly improved students' scientific attitude and process skills (Ahsani & Rusilowati, 2022). This research shows a relationship between STEAM and attitude toward science. Engaging teaching methods, including hands-on experiments, can enhance students' appreciation for science (Park & Jinwoong, 2009; Kim et al., 2023). The curriculum should incorporate contemporary scientific concepts and real-life applications to resonate with students' interests, understanding the confidence levels of students (under-confidence and over confidence) can inform strategies to improve their attitudes toward science (Sheldrake, 2016). The findings emphasize the need for educators to adopt varied teaching strategies to enhance students' interest and engagement in science. The average attitude percentage across multiple domains was moderate, indicating that while students appreciate science, there is potential for development in fostering a deeper interest and comprehension.

CONCLUSION

From the resulting attitude toward science, each sub-scale analysis score revealed that usefulness had the highest N-Gain score in the experiment class, with 0.44 N-Gain score and indicated as medium improvement. As in the control class, the highest score was in usefulness, with a 0.19 N-Gain score indicating a low improvement. The lowest score for students' attitudes toward science on each subscale achieved in the experiment and control classes is enjoyableness, with an N-Gain score of 0.045 and 0.03, indicating a low improvement. This was influenced by the timing at the time of data collection. Many factors influenced the environment, such as time limitations and lack of collaboration among students during the project. Even so, students showed an increased attitude toward science compared to the control class.

Nevertheless, the results provide meaningful direction for future research. By applying the STEAM-Design Process to secondary-school students in a specific science domain, this study fills a gap and shows which attitudinal subscales (e.g Enjoyableness, Difficulty, Self-Efficacy, etc) are most responsive. Future research could adopt longitudinal research approaches to examine the stability of these effects over time and refine interventions to better foster the emotional engagement of learners, such as making the learning more fun, meaningful, or personally relevant. Since the results found relatively low gains in "enjoyableness"

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