CHAPTER III
RESEARCH METHODOLOGY

3.1 Research Method

This research applied a quasi-experimental method with a pretest-posttest. According to Fraenkel et al. (2012), a quasi-experiment is a type of experimental research design that does not involve random assignment. This design was used because the random assignment of students to groups was not feasible, but a comparison was still needed to examine the effect of the learning model. In this study, two groups were involved, the experimental group used STEM-PjBL with the EDP learning model, while the control group used the STEM-PjBL learning model. Both groups carried out a project by building a simple hydroelectric power.

3.2 Research Design

This research used a non-equivalent pretest-posttest design. According to Creswell & Creswell (2018), this design is used when two groups (experiment and control) are selected without random assignment. This design was used because of the research conducted in school, which involved classes (groups) already formed by the school. A pretest and posttest were given to both groups to compare their learning outcomes. The design is shown in Table 3.1.

Table 3.1 Research Design of Non-Equivalent Pretest-Posttest

Class	Pre-test	Treatment	Post-test
Experiment	O_1	X_1	O_2
Control	O_1	X_2	O_2

(Creswell & Creswell, 2018)

O_1: Pre-test of students' renewable energy awareness and critical thinking

X_1: Implementation of STEM-PjBL with EDP

X_2: Implementation of STEM-PjBL without EDP

O_2: Post-test of students' renewable energy awareness and critical thinking

3.3 Population and Sample

The population in this study was 8th-grade students at one of the public junior high schools in Kota Bandung, West Java, Indonesia, that used *Kurikulum Merdeka*. The population of this study consisted of 69 students. From this population, a total of 60 students were selected as the sample, divided into two classes: 30 students in the experimental group and 30 students in the control group. The non-probability convenience sampling technique was used in this study. This technique was used because respondents are chosen based on their convenience and availability, rather than being chosen randomly (Creswell & Creswell, 2018). The details of the research sample are shown in Figure 3.2.

Table 3.2 The Details of the Research Sample Based on Gender

Gender	Experiment Class		Control Class	
	Frequency	Percentage	Frequency	Percentage
Male	13	43.3%	14	46.7%
Female	17	56.7%	16	53.3%
Total	30	100%	30	100%

3.4 Hypothesis

The hypothesis of this research are:

1. Renewable Energy Awareness

   H_0: There is no significant difference in students' renewable energy awareness between the group using STEM-PjBL with EDP and the group using STEM-PjBL without EDP.

   H_1: There is a significant difference in students' renewable energy awareness between the group using STEM-PjBL with EDP and the group using STEM-PjBL without EDP.

2. Critical Thinking Skills

   H_0: There is no significant difference in students' critical thinking skills between the group using STEM-PjBL with EDP and the group using STEM-PjBL without EDP.

H_1: There is a significant difference in students' critical thinking skills between the group using STEM-PjBL with EDP and the group using STEM-PjBL without EDP.

3. Correlation Between Students' Performance and Renewable Energy Awareness

   H_0: There is no significant correlation between students' performance and renewable energy awareness in groups using STEM-PjBL with and without EDP.

   H_1: There is a significant correlation between students' performance and renewable energy awareness in groups using STEM-PjBL with and without EDP.

4. Correlation Between Students' Performance and Critical Thinking Skills

   H_0: There is no significant correlation between students' performance and critical thinking skills in groups using STEM-PjBL with and without EDP.

   H_1: There is a significant correlation between students' performance and critical thinking skills in groups using STEM-PjBL with and without EDP.

3.5 Assumptions

1. STEM projects gives a more positive impact on students than the conventional method, especially for students' critical thinking and awareness about renewable energy.
2. Hydroelectric power STEM project with hands-on activity gives students the opportunity to explore and experience more about renewable energy technology applications that can solve environmental issues.
3. Students have adequate time to complete their projects and analyze the data with good working equipment.

3.6 Research Instrument

This research used two types of instruments to measure each of the dependent variables. All of them were given to the students before learning (pre-test) and after learning (post-test). In addition, students' performance during the project implementation was measured using worksheets designed based on the learning model in each class. The research instrument is detailed in Table 3.3.

Table 3.3 Research Instrument

Data Collected	Instrument
Students' Renewable Energy Awareness	A 20-item Likert scale questionnaire from Morgil et al. (2006) was adopted by Kacan (2015).
Students' Critical Thinking Skills	10 Open-ended questions from Ennis & Weir (1985) adopted by Ijirana et al.
Students' Performance	Worksheet was designed according to the learning model implemented in each class.

Before being administered to the students, the renewable energy awareness and critical thinking instruments underwent expert judgment and readability testing. The results of the expert judgment are provided in Appendix A.1. The question was tested for readability by involving three 8th-grade students from junior high school as representatives of the target audience, using Bahasa Indonesia. Students' readability test document provided in Appendix A.2.

3.6.1 Students' Renewable Energy Awareness

This instrument used a 5-Likert Scale which was expressed as 5 for Totally Agree, 4 for Agree, 3 for Neutral, 2 for Disagree, and 1 for Totally Disagree. The renewable energy awareness was developed based on by Morgil et al. (2006) adopted by Kacan (2015). A total of 20 items were selected and distributed into five indicators, each of which consists of four statements. The items consisted of both positive and negative statements to reduce response bias. The indicator of renewable energy awareness is listed in Table 3.4.

Table 3.4 Indicator of Renewable Energy Awareness Likert-Scale Questionnaire

No	Indicators	Definition	Number of items	Item distribution
1	Knowledge	Students' understanding of renewable energy concepts, types, and basic information	4	1-4
2	Environmental Impact	Students' views on environmental issues	4	5-8
3	Policy and investment	Students' opinions on policies, global support, and financial investments in renewable energy	4	9-12
4	Attitudes and Opinions	Students' personal feelings or preferences toward renewable energy	4	13-16
5	Education and Social Responsibility	Students' perspectives on the importance of education and media in raising renewable energy	4	17-20
		Total	**20**	

The instrument was evaluated by three science lecturers as experts in science education through expert judgment. They assessed the items based on clarity, relevance, and appropriateness for junior high school students. After being revised based on expert judgment and readability testing, the final full version of the questionnaire is provided in Appendix A.3. An example of the statements used in the instrument is shown in Table 3.5.

Table 3.5 The Example of the Renewable Energy Awareness Statements

Category	Statement in Bahasa	Statement in English
Knowledge	*Menggunakan energi terbarukan tidak akan mengurangi penggunaan bahan bakar fosil*	Students' understanding of renewable energy concepts, types, and basic information
Environmental Impact	*Saya tidak percaya bahwa pemanasan global dapat menyebabkan masalah yang sangat penting*	Students' views on environmental issues

Category	Statement in Bahasa	Statement in English
Policy and investment	*Dana yang dikeluarkan pemerintah untuk penggunaan energi terbarukan dan sumbernya harus ditingkatkan agar lebih efektif dan rasional*	Students' opinions on policies, global support, and financial investments in renewable energy
Attitudes and Opinions	*Saya tidak memilih energi terbarukan karena menurut saya energi terbarukan tidak mudah digunakan meskipun dibutuhkan lingkungan*	Students' personal feelings or preferences toward renewable energy
Education and Social Responsibility	*Saya percaya pendidikan di sekolah mengenai energi terbarukan dan tidak terbarukan itu penting*	Students' perspectives on the importance of education and media in raising renewable energy

3.6.2 Students' Critical Thinking Skills

To assess students' critical thinking skills on the topic of renewable energy, this study uses an open-ended essay question. A total of 10 questions were developed based on five indicators from Ijirana et al. (2022). The questions were scored using a rubric based on the critical thinking skills assessment rubric from Ennis & Weir (1985), which was adapted by Ijirana et al. The test was given as a pre-test (before treatment) and a post-test (after treatment). The indicators are shown in Table 3.6

Table 3.6 An Indicator of Critical Thinking Skills Open-Ended Question

No	Indicators	Indicators definition	Question number	Total
1	Strategies and tactics/determining actions	Students' ability to identify the problem related to the use of fossil fuels or renewable energy and has a logical solution as an action	1,2	2
2	Developing basic skills/observing	Students' ability to recognize key concepts of hydroelectric power as renewable energy, especially the influencing factors	3,4	2

No	Indicators	Indicators definition	Question number	Total
3	Inferring/making and evaluating statements	Students' ability to analyze data or information related to the materials or resources of renewable energy	5,6	2
4	Providing further explanation/identifying assumptions	Students' ability to identify and analyze assumptions about renewable energy, such as the benefits or challenges of renewable energy, especially hydropower.	7,8	2
5	Providing elementary clarification/focusing questions	Students' ability to clarify and evaluate the information about renewable energy projects.	9,10	2
		Total		10

(Ijirana et al., 2022)

The critical thinking skills assessment criteria rubric is shown in Table 3.7.

Table 3.7 Critical Thinking Skills Assessment Rubric

Indicators	**Assessment criteria**	**Score**
Strategies and tactics/determining actions	Identifying problems, deciding on appropriate actions based on the students' conditions and logical solutions to problems, and drawing conclusions	4
	Writing down the problems, deciding on appropriate actions based on the students' conditions and logical solutions to problems	3
	Writing down the problems, deciding on appropriate actions based on the students' conditions	2
	Writing down the problems	1
	No response	0
Developing basic skills/observing	Writing down the problems in the form of questions, mechanisms of making an authentic assessment, problem-solving strategies, and drawing conclusions	4
	Writing down the problems in the form of questions, mechanisms of making an authentic assessment, and problem-solving strategies.	3

Indicators	Assessment criteria	Score
	The students have the ability to write down the problems in the form of questions and the mechanisms of making an authentic assessment.	2
	The students have the ability to write down the problems in the form of questions	1
	No response	0
Inferring/making and evaluating statements	Assessing the use of appropriate media/materials, selecting other media/materials that can be used, and providing logical explanations correctly	3
	Assessing the use of appropriate media/materials, selecting other media/materials that can be used	2
	Assessing the use of appropriate media/materials	1
	No response	0
Providing further explanation/identifying assumptions	Assumption-based decision making, providing elementary clarifications, conducting an assessment, and providing advanced clarifications	4
	Assumption-based decision making, providing elementary clarifications, and conducting an assessment	3
	Assumption-based decision making and providing elementary clarifications	2
	Assumption-based decision making	1
	No response	0
Providing elementary clarification/focusing questions	Estimation-based decision making, selecting appropriate methods, making an assessment, and giving elementary clarification	3
	Estimation-based decision making, selecting appropriate methods	2
	Estimation-based decision making	1
	No response	0

(Ijirana et al., 2022)

The questions were constructed based on the indicators and designed to align with the rubric (see Table 3.7 or Appendix A.4), assessing students' responses. To ensure content validity, the self-developed critical thinking questions were evaluated by three science lecturers, who served as experts in science education, through expert judgment. They assessed the items based on relevance, clarity, and

appropriateness for assessing critical thinking in junior high school students. Revisions were made based on the experts' feedback and readability test.

Following the expert and readability, the validity and reliability were measured. The validity of each item was determined based on its correlation with the total score, and for reliability, it was measured using Cronbach's Alpha. The validity and reliability results are shown in Table 3.8.

Table 3.8 The validity and reliability results of the critical thinking skills question

Item Number	Validity Sig. (2-tailed)	Reliability	Status	Action Taken
1	0.005	0.824 (Realible)	VALID	USED
2	0.009		VALID	USED
3	0.678		NOT VALID	REVISED
4	0.004		VALID	USED
5	0.000		VALID	USED
6	0.000		VALID	USED
7	0.000		VALID	USED
8	0.000		VALID	USED
9	0.000		VALID	USED
10	0.000		VALID	USED

Out of all the questions, only item number 3 was not valid. However, because the item was still relevant to the indicator and well-aligned with the rubric (as confirmed through expert judgment), the item was revised rather than removed. The reliability of the instrument was tested using Cronbach's Alpha, resulting in a coefficient of $\alpha = 0.824$, which indicates reliability. Raw data and detailed statistical calculations are provided in Appendix A.5 and Appendix A.6. The final version of the critical thinking skills instrument, after revisions and validation, is provided in Appendix A.7.

3.6.3 Students' Performance

Students' performance during the learning process was assessed using students' worksheets that were designed according to the learning stages implemented in each class, and the worksheet captured students' written responses at every stage. The worksheet for the experimental class is provided in Appendix

B.1, and the one for the control class is in Appendix B.2. To help students during the learning process, a learning module was also given and provided in Appendix B.3.

In every meeting, three observers used observation sheets to check whether each group followed the expected learning steps. The observation sheet for the experimental class is included in Appendix B.4, and for the control class in Appendix B.5. After students completed the worksheets, their performance was assessed using a scoring rubric, which is available in Appendix B.6 for the experimental class and Appendix B.7 for the control class.

3.7 Research Procedure

In conducting this research, several administrative documents were prepared and finalized. These documents included research permission letters and confirmation letters from the school, which validated that the study was formally approved and successfully carried out. Although these documents were issued at different stages of the research timeline, they are collectively presented in Appendix C.1 to Appendix C.4 to provide a clear record of the institutional approval and procedural compliance throughout the entire research process.

3.7.1 Preparation Stage

At this stage, the researcher carried out several preparation activities before the research began. Started by deciding the focus of the study, formulating the research question, and reviewing related literature to support the theoretical foundation. Since this research employed a STEM Project-Based model, the researcher designed and tested the project that students would work on, and created learning materials, such as lesson plans and worksheets, that followed the steps of the learning model used in each class.

Additionally, test instruments were developed to measure students' awareness of renewable energy and critical thinking skills. These instruments were reviewed by experts, a readability test was conducted by the students to ensure the instruments were clear and suitable, and they underwent a validity test. Revisions were made based on results and feedback. After all parts were ready, the researcher

continued with the administrative tasks, such as preparing and sending a letter to the school.

3.7.2 Implementation Stage

During this stage, both the experimental and control classes were given a pretest at the beginning. The purpose of the pretest was to assess students' prior knowledge of renewable energy before the learning intervention. After that, the experimental group received learning through STEM Project-Based Learning with EDP learning model based on the Massachusetts Department of Education from Siew et al. (2016) that integrate with George Lucas, adopted from Sumarni & Kadarwati (2020), while the control class followed a STEM Project-Based Learning based on George Lucas, adopted from Sumarni & Kadarwati (2020).

In both classes, students engaged in hands-on projects that involved designing and building hydroelectric power or water turbines. After the treatment ended, a posttest was assessed to both groups using the same instrument as the pretest. The results of the posttest were used to evaluate any changes in students' renewable energy awareness and critical thinking skills after the learning model was implemented. The learning activities in this study were carried out over five meetings, with each meeting lasting two class periods (2 x 35 minutes). The lesson took place from May 5 to June 4, 2025. A complete version of the lesson plan is provided in Appendix D.1. Learning documentation during this stage is provided in Appendix D.2. To make it clear, an overview of the learning stages used during the research process is shown in Table 3.9.

Table 3.9 Overview of Learning Stages

Meetings	Learning Stages	Experiment Class Activities	Control Class Activities
1st meeting	-	Students take a pre-test.	Students take a pre-test.
2nd meeting	Identify the need or problem, or define an essential question	Students identify the problem presented in the video and provide a solution by discussing and answering the questions on the worksheet.	Students identify the problem presented in the video, provide a solution, and formulate relevant questions through discussion and by answering the

Meetings	Learning Stages	Experiment Class Activities	Control Class Activities
			questions on the worksheet.
	Research the need or problem	Students identify the need and problem by answering the questions with the information provided in the module.	-
	Draw/sketch possible ideas/solutions for the problem or design a prototype	Students choose two materials for the turbine blades and draw two water turbines or hydroelectric power with different blade material designs by labeling each of its components.	Students draw a water turbine or hydroelectric power design by labeling each of its components.
	Select the best possible solutions	Students identify the advantages and disadvantages of each blade's materials and choose the best materials for the blade.	-
	Create Schedule	Students organize and complete the project schedule.	Students organize and complete the project schedule.
	Monitoring the Progress	Students write their project development and evaluate any obstacles that arise.	Students write their project development and evaluate any obstacles that arise.
3rd meeting	Assess the progress and test the result	Students design and build their project, test its performance, record the results, perform calculations, and complete a graph based on the collected data.	Students design and build their project, test its performance, record the results, perform calculations, and complete a graph based on the collected data.
4th meeting	Communicate the result	Students complete the worksheet questions and present their results.	
	Evaluate experience	Students reflect on the process of completing their project and the learning that occurred.	Students reflect on the process of completing their project and the learning that occurred.

Meetings	Learning Stages	Experiment Class Activities	Control Class Activities
5th meeting	-	Students take a post-test	Students take a post-test

3.7.3 Completion Stage

After collecting data from the previous stage, the researcher analyzed the results. The data analysis used to compare students' learning outcomes in using STEM PjBL with and without EDP. The results of this analysis were then presented in detail, followed by a discussion and conclusion based on the findings. An overview of the research procedure stages is illustrated in Figure 3.1.

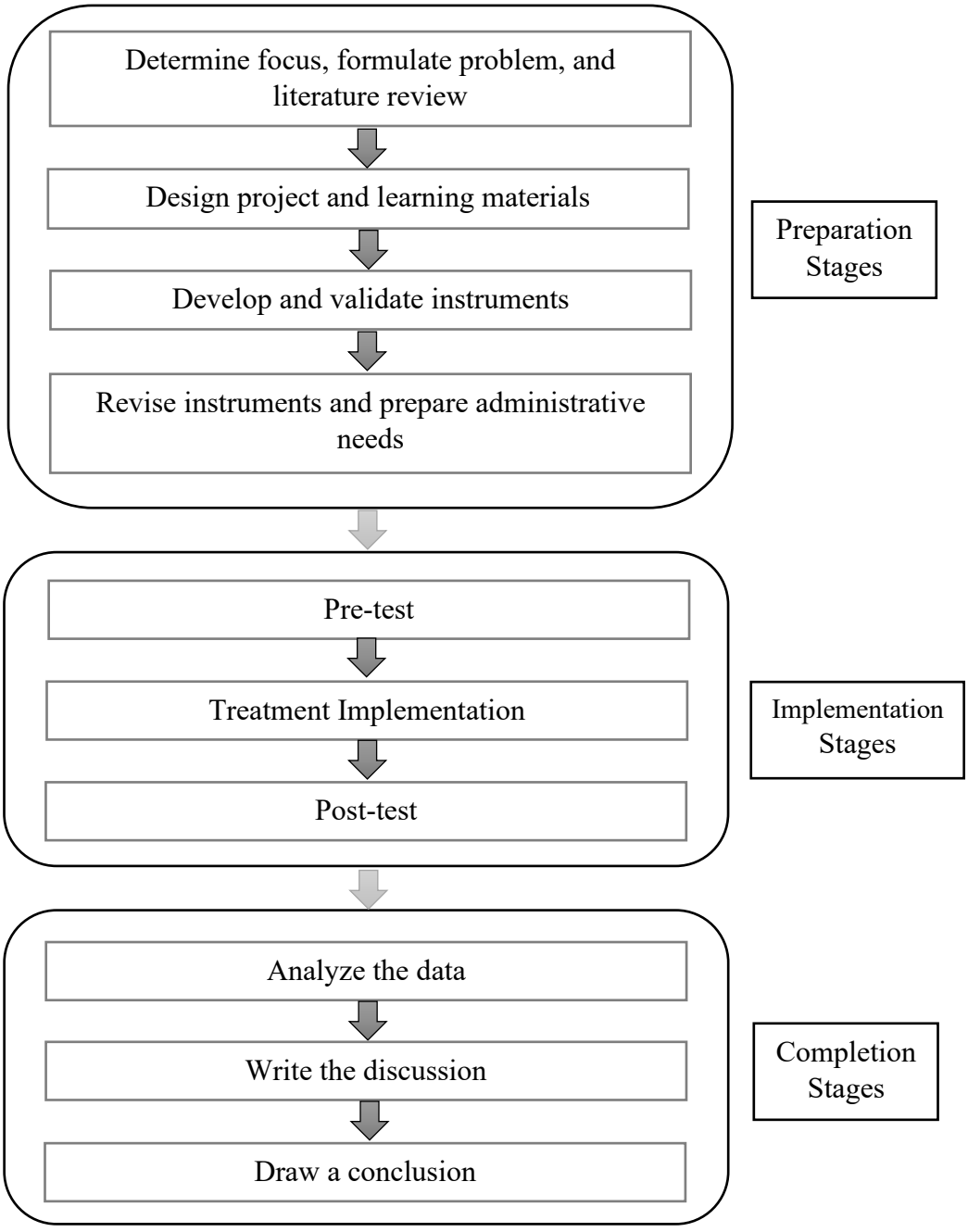

Figure 3.1: Scheme of Research Procedure

3.8 Data Analysis

The data collected in this study were analyzed using quantitative methods. The analysis was conducted to determine whether there were differences and relationships between students' renewable energy awareness and critical thinking skills after the learning process. The result of students' answers as an outcome of

the pre-test and post-test was analyzed. Several statistical tests were used depending on the type and characteristics of the data. The explanations of the data analysis for each variable are presented in the following sections.

3.8.1 Students' Renewable Energy Awareness

The data on students' renewable energy awareness were collected through a questionnaire using a Likert scale from "Strongly Agree" to "Strongly Disagree". The individual Likert scales are indeed ordinal because they have a rank order (Norman, 2010). Since the data were ordinal, normality and homogeneity tests were not required (Sedgwick, 2015). Therefore, non-parametric statistical methods were applied.

1. *Hypothesis testing*

   Hypothesis testing is used to examine whether the hypothesis is accepted or rejected. This test helped to determine whether there were significant differences between groups or changes within groups before and after the learning process.

   a. Wilcoxon Signed-Rank

   The Wilcoxon Signed-Rank Test is a non-parametric statistical method used to compare two related samples. In this study, it was applied to examine whether there was a significant difference between students' pre-test and post-test scores within the same group, with the criteria:

   1) If the significance value (p-value) is less than 0.05, it means there is a significant difference between pre-test and post-test in the class.
   2) If the significance value (p-value) is more than 0.05, it means there is no significant difference between pre-test and post-test in the class.

   b. Mann-Whitney U

   The Mann-Whitney U Test is a non-parametric statistical method used to compare two independent groups. It was used to compare the pre-test, post-test, and n-gain results between the experimental and control classes. When used for pre-test, this test examines whether there is a difference in students' initial awareness between the two groups. In the post-test, this test was used to examine whether different learning treatments caused a significant

difference in students' outcomes. When applied to N-gain scores, it measured whether students in the experimental group experienced significantly greater improvement compared to those in the control group. The criteria are:

1) If the significance value (p-value) is less than 0.05, it means there is a significant difference between the experiment and control groups.
2) If the significance value (p-value) is more than 0.05, it means there is no significant difference between the experiment and control groups.

c. Rank Biserial Correlation

In this study, it was used to determine how strongly the learning method affected students' N-Gain scores on each indicator of renewable energy awareness, with the criteria shown in Table 3.10.

Table 3.10 Interpretation of Rank Biserial Correlations

r	Interpretation
0.8	Strong positive
0.5	Moderate positive
0.2	Weak positive
0.0	No relationship
-0.2	Weak negative
-0.5	Moderate negative
-0.8	Strong negative

(Khamis, 2008)

3.8.2 Students' Critical Thinking Skills

The data on students' critical thinking skills were collected through a 10 essay questions. The analysis involved both descriptive and statistics to examine differences between the control and experimental groups. Before proceeding to hypothesis testing, assumption tests were carried out to determine the appropriate statistical methods.

1. *Pre-requisite Test*

This test needed to determine how the data would be further analyzed using prerequisites include the normality test and homogeneity test. If the data met both assumptions, a parametric test could be used; otherwise, non-parametric methods were applied.

a. *Normality Test*

The normality test was used to determine whether the data were normally distributed. Since the sample of this study is 30 students, the Saphiro-Wilk test was used. Saphiro-wilk are recommended for sample sizes of less than 50 (Saphiro Wilk Sumber). The criteria are:

1) If the significant value (p) > 0.05 mean the data are normally distributed.
2) If the significant value (p) < 0.05 mean the data are not normally distributed.

b. *Homogenity Test*

This test used to assess the variances are equal or not across the group. In this study we used Levene's Test with the criteria:

1) If the sig. Value (p) > 0.05, the data are have equal variance (homogeneous).
2) If the sig. Value (p) < 0.05, the data is are not have equal variance (not homogeneous).

2. *Hypothesis test*

Hypothesis testing was conducted to examine the effectiveness of the learning model on students' critical thinking skills. the data met the assumptions of normality and homogeneity, parametric tests such as t-tests were used. If the data not meet the assumptions, non-parametric tests such Wilcoxon Signed Rank and Mann-Whitney U test were applied.

a. *Paired Sample t-test*

The paired sample t-test is a parametric statistical method used examine whether there was a significant difference between students' pre-test and post-test scores within the same group, with the criteria:

1) If the significance value (p-value) is less than 0.05, it means there is a significant difference between the pre-test and post-test in class.
2) If the significance value (p-value) is more than 0.05, it means there is no significant difference between pre-test and post-test in class.

b. *Independent Sample t-test*

The Independent Sample t-test is a parametric statistical method used to comparing the means scores of two different classes (Rockinson-Szapkiw, 2013). It was used to compare the pre-test, post-test, and n-gain results between the experimental and control classes. When used for pre-test, this test examine whether there is a difference in students' initial awareness between two groups. In post-test, this test used to examine whether different learning treatments caused a significant difference in students' outcomes. When applied to N-gain scores, it measured whether students in the experimental group experienced significantly greater improvement compared to those in the control group. The criteria are:

1) If the significance value (p-value) is less than 0.05, it means there is a significant difference between the experiment and control groups.
2) If the significance value (p-value) is more than 0.05, it means there is no significant difference between the experiment and control groups.

c. *Partial eta-squared effect size*

Partial Eta-squared effect size used to indicate the strength of the effect of a treatment (Rockinson-Szapkiw, 2013). It tells us how much of the result is influenced by the learning activity or method used. The value ranges from 0 to 1, the higher number, the stronger the influence or relationship. Partial eta-squared effect size guidelines are shown in Table 3.11.

Table 3.11 Partial eta-squared effect size guidelines

Partial Eta-Squared	Interpretation
Small	0.01
Medium	0.06
Large	0.138

Cohen's effect size interpretation as cited in Rockinson-Szapkiw (2013)

d. Wilcoxon Signed-Rank Test

The Wilcoxon Signed-Rank Test is a non-parametric statistical technique used to compare two related data sets. In this research, it was applied to examine whether there was a significant difference between students' pre-test and post-test scores within the same group, with the criteria:

1) A significance value (p-value) below 0.05 indicates a significant difference between the pre-test and post-test results in the class.
2) A significance value (p-value) above 0.05 indicates no significant difference between the pre-test and post-test results in the class.

e. Mann-Whitney U Test

This study employed the Mann-Whitney U Test, a non-parametric statistical method, to compare two separate groups. It was applied to the pre-test, post-test, and N-gain data of experimental and control classes. For the pre-test, the goal was to assess whether students from both groups had differing levels of initial awareness. In the post-test, this test was used to examine whether different learning treatments caused a significant difference in students' outcomes. When applied to N-gain scores, it measured whether students in the experimental group experienced significantly greater improvement compared to those in the control group. The criteria are:

1) If the significance value (p-value) is less than 0.05, it means there is a significant difference between the experiment and control groups.
2) If the significance value (p-value) is more than 0.05, it means there is no significant difference between the experiment and control groups.

f. Rank-Biserial Correlation

In this study, it was used to determine how strongly the learning method affected students' N-Gain scores on each indicator of renewable energy awareness, with the criteria shown in Table 3.10.

3.8.3 Correlation Analysis

The data on students' critical thinking skills were collected through a 10 essay questions. The analysis involved both descriptive statistics and statistics to examine differences between the control and experimental groups. Before proceeding with hypothesis testing, assumption tests were conducted to determine the appropriate statistical methods.

1. *Pre-requisite Test*

This test is needed to determine how the data will be further analyzed. The prerequisites include a normality test and a homogeneity test. If the data met

both assumptions, a parametric test could be used, otherwise, non-parametric methods were applied.

a. *Normality Test*

A normality test was used to determine whether the data were normally distributed. The criteria are:

1) If the significant value (p) > 0.05, it means the data are normally distributed.
2) If the significant value (p) < 0.05, it means the data are not normally distributed.

b. *Homogeneity Test*

This test is used to assess whether the variances are equal across the groups. In this study, we used Levene's Test with the criteria:

1) If the sig. Value (p) > 0.05, the data have equal variance (homogeneous).
2) If the sig. Value (p) < 0.05, the data do not have equal variance (not homogeneous).

2. *Hypothesis test*

This test is used to determine students' overall performance difference between two classes. In this test, if the data met the assumptions of normality and homogeneity, parametric tests such as t-tests were used. If the data do not meet the assumptions, non-parametric tests such as Wilcoxon Signed Rank and Mann-Whitney U test were applied.

a. *Independent Sample t-test*

The Independent Sample t-test is a parametric statistical method used to compare the mean scores of two different classes (Rockinson-Szapkiw, 2013). It was used to compare the performance results of students between the experimental and control classes. The criteria are:

1) If the significance value (p-value) is less than 0.05, it means there is a significant difference between the experiment and control groups.
2) If the significance value (p-value) is more than 0.05, it means there is no significant difference between the experiment and control groups.

3. *Correlation test*

Correlation analysis was performed to examine the relationship between students' performance in each class and students' performance, their renewable energy awareness, and critical thinking scores. This analysis provided insight into how students' engagement in project-based activities was associated with learning outcomes. If the data met assumptions, Pearson correlation was used, and if not, or the data were ordinal, Spearman's rank correlation was applied.

a. *Pearson Correlation*

Pearson's correlation measures the linear relationship between two continuous and normally distributed variables. It assumes the data meet the requirements of normality and homogeneity. The correlation strength interpretation of the Pearson correlation is shown in Table 3.12.

b. *Spearman's Rank Correlation*

Spearman's rank correlation is a non-parametric method that assesses both the strength and the direction of the relationship between two variables, particularly when data are ordinal or when Pearson correlation assumptions are not fulfilled. The correlation strength interpretation of Spearman's rank correlation is shown in Table 3.12.

Table 3.12 Correlation Coefficient Interpretation

Correlation Coefficient	Interpretation
0.00 - 0.19	Very Weak
0.20 - 0.39	Weak
0.40 - 0.59	Moderate
0.60 - 0.79	Strong
0.80 - 1.0	Very Strong

Adapted from Hauke and Kossowski (2011) by Nakawala et al. (2025)