CHAPTER III
RESEARCH METHODOLOGY

3.1 Research Method and Research Design

a. Research Method

Quantitative Method used as the method of this research. Quantitative research rigorously tests objective theories by analyzing the relationship between variables (Creswell & Creswell, 2018). Quantitative research involves making conclusions from the results for the research questions, hypotheses, and the larger significance of the results (Creswell & Creswell, 2018). In this research, researchers wanted to find out whether could enhance Student Understanding and Creativity through STEAM learning in electricity material.

b. Research Design

Pre-experimental Design and Pre-test Post-test is chosen as the experimental research methods. In pre-experimental designs, the researcher studies a one group and implements an intervention during the experiment. This design does not have a control group to compare with the experimental group (Creswell & Creswell, 2018). The pre-experimental design was used to discover the effect of STEAM Learning approach implemented by the researcher to students' STEAM Understanding and Creativity. Therefore, the researcher will know whether any change occurred due to the implementation of STEAM Learning approach in learning electricity. Students' understanding was assessed using an objective test of cognitive levels C1 (remembering), C2 (understanding), C3 (applying) and 25 multiple-choice questions based on the Bloom Classification (Anderson & Krathwohl, 2001). All test assignments were analyzed by experts as part of the assessment and tested to the students. Test task results are used, modified, or deleted after the evaluation process. The objective test analyzed using SPSS. The reliability score is 0.60 which is moderate reliability. Reliability is the constancy of

stating that reliability refers to an understanding that the instruments used in research to obtain information used can be trusted as a data collection tool and are able to reveal actual information in the field. This research followed the One-Group Pretest Posttest Design. Prior to receiving treatment, a pretest was administered to gauge participants' initial understanding. Following treatment, a posttest was conducted to measure any changes in their understanding.

Table 3.1

Pre-Experimental Research Design

Pre-test	Implementation	Post-test
Students' Understanding – Pretest	Experiment Paper Circuit Project – implementation of STEAM learning	Students' Understanding – Posttest

3.2 Population and Sample

In this research, location that will be conducted at one of school in Bandung and Cimahi Junior High School. The characteristic of the chosen school is they conduct Merdeka curriculum and Cambridge curriculum as they curriculum. In this research, sample is 8th and 9th student (adapted to the curriculum used in the school) and will be one class (50 students) as a sample of this researchthat will be implementing Project-based Learning through Paper Circuit Project Experiment. The distribution of the sample was characterized by gender provided in Table 3.2

Table 3.2

Detail of The Sample Based on Gender

Gender	Frequency	Percentage
Male	34	68%
Female	16	32%
Total	50	100%

3.3 Research Instrument Analysis Based on Expert Judgment

The research instruments were analyzed base on expert judgment. The expert judgment consists of 1 lecture in Science Education Department. The judgement for this research instrument shown on the Table 3.3 and validation instrument expert judgement can be found in appendix A.2

Table 3.3
List of judgement

No.	Name	Occupation
1	J1	Science Education Lecture (Master in Physics)

From the judgements the test item and the worksheet lab need some improvement and revise. There was some the question should be revise. Here are the general comments from the expert judgements:

a. Revise the words that is still have a mistake
b. Revise the cognitive dimension, it should be C2, not C3
c. Data for question must be based on experimental results
d. Improve aspects of the indicators
e. Learn and search more about collective data about currents

3.4 Analysis Based on Validation

The cognitive test was analyzed based on student's validation and the judgments from the expert. The student's validation was conducted in public school on 8^{th} grade students. The participant student's validation were 30 students. The instrument consists of 30 questions in multiple choice. Cognitive domain based on the assessments of the revised Bloom's Taxonomy. Data analysis for student validation using SPSS.

1) Validity

Validity describes how accurately a concept is measured in quantitative research. According to (Fraenkel et al., 2011) the process of collecting and

analyzing evidence information to support inferences is known as validation. There are several methods for gathering evidence. The important point is to understand that validity refers to the degree to which evidence supports any conclusions made by a researcher based on data collected using a certain instrument. SPSS software was used in the process of validity of the instrument. The result from SPSS for validity in this research instrument shown on Table 3.4

Table 3.4

Result Validation

Question	Validation	Question	Validation
1	.411	16	.354
2	.423	17	.386
3	.352	18	.379
4	.367	19	.517
5	.054	20	.611
6	.522	21	.536
7	.588	22	.435
8	.137	23	.311
9	.052	24	.214
10	.386	25	.338
11	.310	26	.382
12	.309	27	.379
13	.091	28	.431
14	.367	29	.294
15	.399	30	.094

The data showed the validity of all the test item. The Table 3.5 shown about the criteria of each item.

Table 3.5

Validity Criteria

Correlation Coefficient	Validity Criteria
$0.80 < r \leq 1.00$	Very High
$0.60 < r \leq 0.80$	High
$0.40 < r \leq 0.60$	Enough
$0.20 < r \leq 0.40$	Low
$0.00 < r \leq 0.20$	Very Low

(King, 1993)

2) N-Gain

The pretest posttest instrument can be used after testing its validity, then data on student pre-test and post-test scores are obtained. The next step is to calculate the normalized gain (n-gain). Normalized gain test is to determine the categories of students understanding improvement. Gain is the difference between the posttest and pretest scores. According to (Hake, 1999) the gain score can be obtained by following formula:

$$G = Sf - Si$$

where:

G = Gain Score

Sf = Post test Score

Si = Pre-test Score

The next step is to calculate the gain and normalized gain (n-gain). Gain is the difference between the posttest and pretest scores**.** N-gain can be calculated by the formula:

$$\text{N-Gain} = \frac{\textit{Pretest Score} - \textit{Pretest Score}}{\textit{Max Score} - \textit{Pretest Score}}$$

(Meltzer, 2002)

The N-Gain score was calculated using the formula provided. Subsequently, the interpretation of the N-Gain score was cross-referenced with an interpretation table tailored for this purpose. The interpretation of the N-Gain score is detailed in the Table 3.6 presented below.

Table 3.6

N-Gain Classification

Criteria	N-Gain Value
High	≥ 0.7
Medium	$0.3 \leq$ N-Gain < 0.7
Low	< 0.3

(Hake, 1999)

3) Reliability

Reliability is a crucial factor in determining the accuracy and credibility of the gathered information. It refers to the consistency and trustworthiness of the research instruments that are employed to collect data. The reliability of these tools ensures that they are dependable and can yield precise and trustworthy real-world data. This is of utmost importance in ensuring the validity of research findings and conclusions (Riskawati, 2018). The Kuder-Richardson methodology, specifically formulae KR20 and KR21, is perhaps the most often used method for assessing internal consistency (Fraenkel et al., 2011). SPSS software was used in the process of reliability of the instrument. The result for reliability score in this research instrument shown on Table 3.7.

Table 3.7

Reliability Data

Subject	Score	Subject	Score
S1	26	S16	18
S2	25	S17	21
S3	23	S18	17
S4	21	S19	23
S5	25	S20	21
S6	13	S21	21
S7	26	S22	28
S8	24	S23	14
S9	24	S24	12
S10	26	S25	22

S11	17	S26	18
S12	26	S27	17
S13	23	S28	25
S14	21	S29	26
S15	21	S30	24

Based on responses from a Google Form, data was collected from 30 students regarding their total score of correct answers. Table 3.8 displays the results of a reliability test conducted on this data.

Table 3.8

Reliability Result

Subject	Score
Reliability Test	0.605

In order to comprehend the Reliability Interpretation analysis presented in the Table 3.9.

Table 3.9

Reliability Interpretation

Correlation Coefficient	Reliability Criteria
$0.80 < r \leq 1.00$	Very High
$0.60 < r \leq 0.80$	High
$0.40 < r \leq 0.60$	Enough
$0.20 < r \leq 0.40$	Low
$0.00 < r \leq 0.20$	Very Low

From the data value of the reliability test is 0.60. according to Wiratna Sujerweni (2014), the test item is said to be reliable if the Cronbach alpha value is > 0.60. The reliability score is 0.605 which means high reliability. Reliability refers to the consistency and trustworthiness of the instruments used in research for collecting data. It ensures that the obtained information is accurate and reflects the reality in the field (Riskawati, 2018).

3.5 Research Instrument

Research instrument is required to collect the data. The research conducted involved the utilization of various instruments to assess both students' understanding and creativity. The instruments used for this assessment are described below.

1) Students' Understanding

There exist various research instruments utilized in this study. Those instruments are described as follow: The pretest was given before conducting the treatment to know STEAM understanding in basic dynamic electricity subject of students. Worksheet was used to measure the creativity implementation of STEAM learning in the class. The worksheet contains the steps taken by students which will be assessed whether students can make their own projects or not. In the implementation, students create Paper Circuit Project, in this observation Project-based STEAM Learning used to test students' Understanding and Creativity. Post-test was given after the implementation conducting the treatment to know enhance STEAM understanding in basic Electricity subject of students. In Table 3.10 shown the STEAM lesson plan and the lesson plan for 4 meeting can be found in Appendix A.3.

Table 3.10.

STEAM Lesson Plan

Meeting	Activity	Science Concept	Developed STEAM
Meeting 1st	STEAM understanding and creativity Pre-test	- Electric Current - Resistance - Ohms' Law - Potential Difference	**Science** Students learn the basic principles of electricity such as electric current, voltage, resistance, and power. **Technology** Students use

Meeting	Activity	Science Concept	Developed STEAM
Meeting 2nd	Create Circuits Diagrams by using Paper Circuit (LED, Battery and Cooper tape)	- Series and parallel circuit	technology in this project, including batteries, wires, and light sources like LEDs. **Engineering** Students learn the basic principles of electrical engineering and build more complex circuits. They will also apply engineering principles to solve problems in their project.
Meeting 3rd	- Experimental: Series and parallel construction with PaperCircuits - Combined series and parallel construction - Making variation Paper Circuits Project. - Create a Circuit and Art Design (drawing) Modifying the Circuit	Electric Current: - Series and parallelcircuit - Potential Difference - Resistance - Ohms' Law - Potential Difference	**Art** Students use art elements in this project, such as paper, scissors, and other decorative materials to make their circuits look attractive and eye-catching. **Mathematics** Students are able to apply Ohm's Law students will learn basic math in relation to electrical principles, such as calculating voltage, current, resistance, and power.
Meeting 4th	- STEAM Understanding Post-test	- Electric Current - Resistance - Ohms' Law Potential Difference	**Science** Students learn how simple circuits work and how different materials affect the flow of electricity. Students are able to recall the principle of series and parallel circuit.

Meeting	Activity	Science Concept	Developed STEAM
			Technology Students use design software to plan and design their circuits. **Engineering** Students apply engineering principles to design and build circuits with the appropriate resistance. They will also troubleshoot and modify their circuits to achieve the desired results. **Mathematics** Students measure and record data to test their circuits.

Cognitive aspect test is in form multiple choice question in order to describe the students' cognitive ability in understanding the concept based on the Bloom Taxonomy revised. The dimension cognitive level is measured is from C1 to C3. Table 3.11 shown the blue print planning for the test item.

Table 3.11

The blue print planning for test item

Sub-Topic	Cognitive Process Dimension and Number of test Item		
	C1	**C2**	**C3**
Current	1,2,4,5,8,	19	28
Ohm Law	6	12,13,17,20,	24
Resistance		15	
Circuit	3,7,9,26,29	10,11,16,21,23,25	

Power Practical Component	14, 22,26,27,30,18

This research measures students' understanding so that questions made from C1 to C3 must fulfill the electricity topic.

To ensure the validity and reliability of the objective test, expert judgment was sought, and the test was validated by administering it to 30 students who had already studied the electricity topic. The validation process involved analyzing the results using SPSS, which encompassed validity Score, Validity Criteria and Information. The compilation of test items is displayed in Table 3.12

Table 3.12

Result of each Questions

Question Number	Validity Score	Validity Criteria	Information
1	.411	Enough	Valid
2	.423	Enough	Valid
3	.352	Low	Valid but need some revision
4	.367	Low	Valid
5	.054	Very Low	Not Valid
6	.522	Enough	Valid
7	.588	Enough	Valid
8	.137	Low	Not Valid
9	.052	Very Low	Not Valid
10	.386	Low	Valid
11	.310	Low	Valid but need some revision
12	.309	Low	Valid but need some revision
13	.091	Very Low	Not Valid
14	.367	Low	Valid
15	.399	Low	Valid

Question Number	Validity Score	Validity Criteria	Information
16	.354	Low	Valid but need some revision
17	.386	Low	Valid
18	.379	Low	Valid
19	.517	Enough	Valid
20	.611	High	Valid
21	.536	Enough	Valid
22	.435	Enough	Valid
23	.311	Low	Valid but need some revision
24	.214	Low	Valid but need some revision
25	.338	Low	Valid but need some revision
26	.382	Low	Valid
27	.379	Low	Valid but need some revision
28	.431	Enough	Valid
29	.294	Low	Valid but need some revision
30	.094	Very Low	Not Valid

From the Table 3.12 it was showed that 25 questions can be used for this research instruments, but some the questions need to improvement with the revising the questions. On the other hand, there are five questions that need to be replaced with more valid ones. Consequently, the final blueprint for the objective test was refined to include 25 questions, as illustrated in Table 3.13

Table 3.13

The blue print planning for test item after Revision

Sub-Topic	Cognitive Process Dimension and Number of test Item		
	C1	**C2**	**C3**
Current	1,2,4,8,	15	24
Ohm Law	5	9,13,26,	20
Resistance		11	

Circuit	3,6,9	7,8,12,17,19,21
Power		10,
Practical Component		14,18,22,23

2) Students' Creativity

To measure creativity, the Creativity Product Analysis Matrix (CPAM) was utilized. This tool was developed by (Besemer & Treffinger, 1981). The data gathered from students' creativity is based on a creative product created by students as part of a STEAM project-based learning activity. For each criteria of creativity, students' inventiveness is graded on a scale of 1 to 3. The criterion employed is germinal, original, valuable, helpful, well-crafted, expressive, and unique. In Table 3.14 shown the creativity product analysis matrix indicator and for the worksheet experiment can be found in appendix A.4

Table 3.14

Creativity Rubric

Creative Dimension	**Criterion**	**Score**		
		1	**2**	**3**
		Lower	**Medium**	**Higher**
Novelty:	Germinal	The product is inspiring other with the creation	The product is inspiring others to try something new	The product is inspiring others to try something new by directly give ideas to develop more product design
	Original	Students mostly use the previous finding as their product idea	Students use the previous finding as their idea, but they make a modification of the product	The product idea comes from their own understanding
Resolution:	Valuable	The product is not	The product is compatible with	The product is compatible with the

Creative Dimension	Criterion	Score		
		1	**2**	**3**
		compatible with the purpose and not relates to the concept	the purpose and not relates to the concept	purpose and relates to the concept
	Useful	The product can be used once	The product can be used continuously with a certain requirement	The product can be used continuously without any requirement
Elaboration:	Well Crafted	The product is done well	The product is done well with the goodlooking design	Students take an effort to give interesting product design by using some material
	Expressive	The product is presented with lacking body language and need to control speaking tone, not understandable	The product is presented with lacking body language and need to control speaking tone, not understandable	The product is presented in a communicative way (using effective body language and clear voice) and understandable manner

(Hanif et al., 2019)

The total score is obtained by converting the score into a percentage. The technique of combining scores into percentages is used as follows:

$$NP = \frac{R}{SM} \times 100\%$$

Where:

NP = Percentage

R = Raw Score

SM = Maximum Score

Interpretation of student creativity percentage scores in certain categories as shown in Table 3.15.

Table 3.15

Score Criteria

Percentage (%)	Criteria
86-100	Very Good
76-85	Good
60-75	Enough
55-59	Low
<54	Very Lack

3.6 Data Analysis

This study analyzed the results of the pretest and posttest in one class using SPSS software. Data analysis is broken down into numerous assessments to determine the understanding and creativity in electricity topic. During the data assessment, this conducted the following statistical test:

1. Pre-requisite test

   Prerequisite tests, including a normality test and a homogeneity test, are imperative for determining which data should be utilized for supplementary testing.

a. Normality test

   The normality test is carried out in order to test the distribution of data on a group or variablethat is normally distributed or not. In this study, the result of the pretest and posttest were tested using the Kolmogorov-Smirnov test.

If the data follows a normal distribution, then parametric testing can be used for analysis. However, if the data does not follow this distribution, nonparametric testing is necessary. To determine whether the data follows a normal distribution, SPSS program provides the following criteria for Normality testing:

- If the significance value is < 0.05, then the data is not normal
- If the significance value is > 0.05, then the data is normal

b. Homogeneity test

Homogeneity test was carried out to find out whether samples from the control class and experimental class came from uniform populations or not. In this study the test used the Levene test because the data is in the form of a scale. To carry out the homogeneity test using the SPSS program, the following criteria were employed:

- If the significance value is >0.05, then the data is not homogeneous
- If the significance value is < 0.05, then the data is homogeneous

3.7 Hypothesis

H.0 there is no significant difference of students' understanding and creativity between pre-test and post-test after implementation electricity material and made paper circuit project in STEAM learning.

Ha. there is significant difference of student's understanding and creativity between pre-test and post-test after implementation electricity material and made paper circuit project in STEAM learning.

Hypothesis will be measure with Willcoxon test. Willcoxon test using SPSS software are as follows:

- If the significance value is < 0.05, then the data is significant difference between pre-test and post-test
- If the significance value is > 0.05, then the data is not significant difference between pre-test and post-test

3.8 Research Procedure

The research procedure unfolds through three distinct stages: preparation, implementation, and completion. Each of these stages is outlined and elaborated upon below.

1) Preparation Stage

The preparatory stage involves several important tasks. This includes collecting problem data and research data from various academic journals related to the Project-based STEAM Learning, especially in understanding and creativity. As an important preparatory step, the creation of objective tests and worksheets is carried out. To ensure the robustness and accuracy of these instruments, they undergo rigorous evaluation by experts in the field and are subject to a validation process. Initial test item, validation form, worksheet and lesson plan can be found in Appendix A

2) Implementation Stage

Moving on to the implementation stage, the primary focus is to gather data from the participating students. The actual learning process is conducted in offline settings, involving four distinct classes of 8^{th} and 9^{th} grade students. The detailed breakdown of each instructional session is thoroughly documented and provided in Table 3.16, which serves as a comprehensive reference for the entire process and documentation picture can be found in Appendix D

Table 3.16

The Implementation Activities

Meeting	Activity
Meeting 1st	In the first meeting, before teacher delivering the material about electricity students were prompted to complete the pre-test
Meeting 2nd	Student do the experiment: create circuitsdiagrams by using Paper Circuit (LED, Battery and Cooper tape) – first project

Meeting	Activity
Meeting 3rd	Student do the second Experiment: - Making variation PaperCircuits Project. - Create a Circuit and Art Design (drawing) - Modifying the Circuit
Meeting 4th	Towards the conclusion of the class, students were prompted to complete the post-test

3) Completion Stage

In the final phase, which is the completion stage, the accumulated data is carefully analyzed and discussed. This involves using statistical methodologies to rigorously analyze the gathered information. Once the data analysis process is completed, the research paper is finalized. To provide a summary of the overall research progression, a visual flowchart that encapsulates the entire process is presented in Figure 3.3. This gives an overview of the procedural stages and how they relate to each other at a glance.

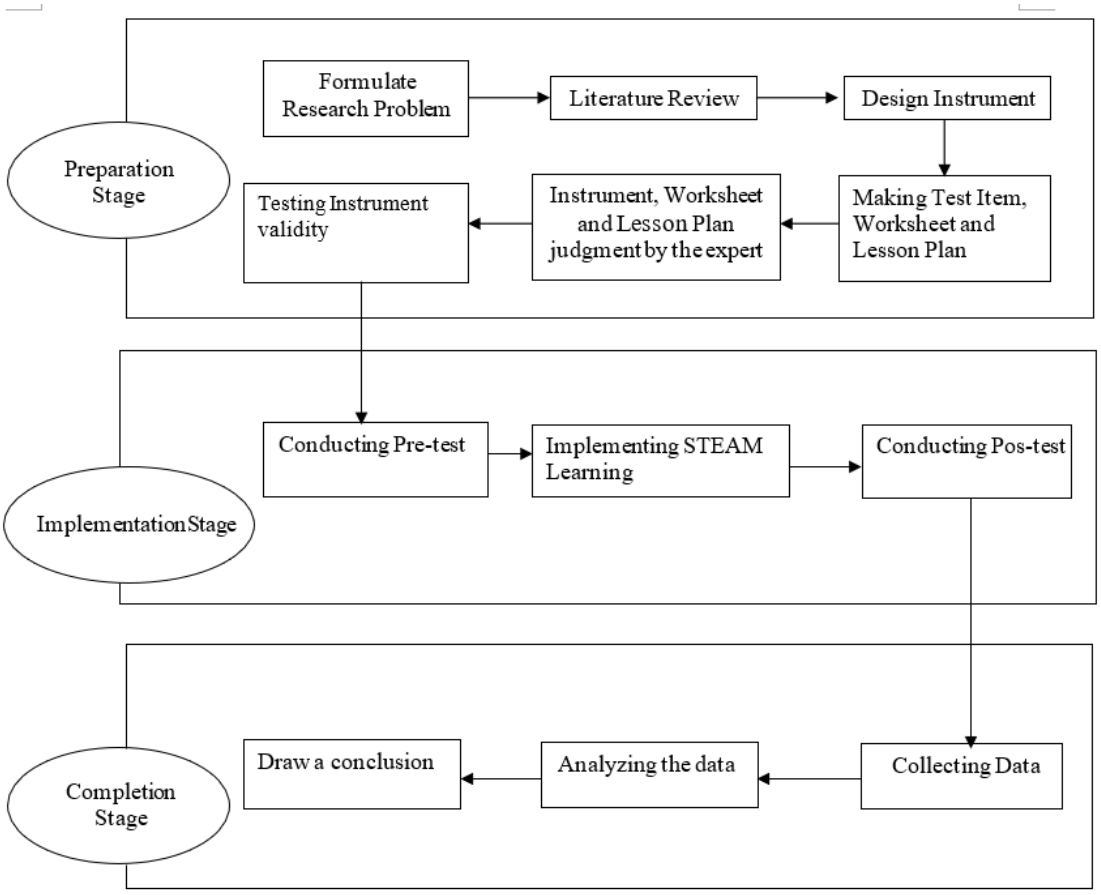

Figure 3.1 Flowchart of The Research Procedure