CHAPTER III
RESEARCH METHODOLOGY

3.1 Research Method and Design

3.1.1 Research Method

The research method used in this research was Pre-Experimental method using one group research without classroom control. This method was used to analyze the interrelationship within the variables and investigate external factors might influenced on the research result (Fraenkel and Warren, 2012). In this research, the researcher using STEM Learning as the independent variable and students' STEM Literacy as the dependent variable.

3.1.2 Research Design

The design was used in this research is one group pretest and posttest design. This design is able to measure the impact of the treatment given before and after getting implemented in one group research subject (Fraenkel and Warren, 2012). This design is appropriate with the purpose of this research which to investigate the impact of STEM learning using Arduino-Protoboard Based Experiment towards students' STEM Literacy. In this research, students were given a test to know their prior knowledge or pretest (O_1), STEM Learning using Arduino-Protoboard based experiment as the treatment on learning process (X), and after the concept given the treatment of the final posttest will be conducted (O_2). The research design is shown in Table 3.1.

Table 3.1. One Group Pretest and Posttest Design

Pretest	Treatment	Posttest
O_1	X	O_2

(Fraenkel and Warren, 2012)

Where:

O_1 = Pretest X = Treatment O_2 = Posttest

3.2 Population and Sample

The research was conducted in Private Secondary School in Bogor which applied Indonesia National Curriculum 2013 and Cambridge IGCSE curriculum in learning process. Population of this research was all of the 8th grade students in the school. The sample is 16 students of class 8N which applied inclusive learning process inside the classroom. The sampling technique is Simple Random Sampling. Fraenkel and Warren (2012) stated that simple random sampling is one in which each and every member of the population has an equal and independent chance of being selected.

3.3 Operational Definition

In order to conduct the research in accordance with the expected aims and avoid misunderstanding, operational definitions need to be elaborated as follows:

3.3.1.1 The stages of STEM learning which implemented in this research is based from Anne Jolly (2014), there are: *Involve students in productive teamwork*, *Immerse students in hands-on inquiry and open-ended explorations, Focus on real world issues and problems, Guided by engineering design process, Apply rigorous mathematical and science content,* and *Allow multiple right answers and reframe the failure during learning.* STEM Learning implementation is evaluated based on lesson plan, peer observation, and observation sheets.

3.3.1.2 STEM literacy in this research is the competence of students that covers all aspects in STEM literacy such as Science Literacy, Technology Literacy, Engineering Literacy, and Mathematical Literacy. The indicators are the concept of electricity which suitable with STEM literacy indicators according

to Zollman (2012). This competence is measure using multiple choice (pre-test and post-test), and students' worksheet.

3.4 Assumption

The assumptions that used as the foundation of this study are:

3.4.1 STEM education approach not only increase students' interest but also improves their thinking and practical skill in learning magnetism, electricity, and electrical energy (Anwari et al., 2012).

3.4.2 The implication of technology and engineering during instruction will increase students understanding in science and mathematics (Hammonds, 2012).

3.4.3 Arduino laboratory activity can increase students' learning satisfication because they enable to reflect the meaningful learning value by themselves after working with Arduino in learning science (Rubio et al., 2013).

3.5 Hypothesis

Hypothesis that is tested in this study are as follow:

H_0: There is no significant improvement on students' STEM literacy in learning electricity using STEM Learning helped by Arduino-Protoboard.

H_1: There is significant improvement in students' STEM literacy in learning electricity using STEM Learning helped by Arduino-Protoboard.

3.6 Research Instrument

The instrument is an essential component to obtain the data of a research. The research instrument which used in this research consist of:

a. Observation Sheet

The observation sheet was used to gain the qualitative data in this research. The observation sheet was used to measure the implementation of STEM learning in the class. As a measurement tool, the steps on the observation sheet were conducted bt the researcher and student will assume the appropriateness of STEM Learning implementation.

b. Objective Test

The objective test is the instrument which used to test students' STEM Literacy. There are 27 multiple choice questions about electricity that covers four aspects of STEM Literacy; Science literacy, Technology literacy, Engineering literacy, and Mathematics literacy. In this research, the test was given in both pretest and posttest. Pretest were given to know students' basic STEM Literacy before the researcher conducting the treatment of STEM learning, while the posttest were given to know the improvement of students' STEM Literacy. The item constructed based on STEM literacy indicator from Allan Zollman study in 2012.

Table 3.2 shows the blue print of objective test before being analyzed.

Table 3.2 Blue Print of STEM Literacy-Based Test

No	Aspects of STEM Literacy	Questions	Total	Percentage
1	Science Literacy	1,2,3,4,5,6,8,9	8	30%
2	Technology Literacy	7,10,11,12,13	5	18%
3	Engineering Literacy	14,15,16,17	4	15%
4	Mathematical Literacy	18,19,20,21,22,23,24,25, 26,27	10	37%

After all the items judged by the experts, then the instrument was tested to the 10th grade students who have learned about electricity. The students' answers were analyzed using a statistical software, namely ANATES (the result of ANATES is attached on Appendix). As a result, there are only 25 items were selected and used as the fixed instrument. The new blue print of objective test items after being analyzed and revised shown in Table 3.7

3.7 Instrument Development and Analysis

The instrument of this research was developed according several steps before getting implemented. The instrument development started by analyzing the four aspects of STEM Literacy and indicators which suitable with the electricity concept. The researcher later formulates the instrument to be used as pretest and posttest. Then the instruments were judged by the experts and select which items need to be revised. The revised instrument later tested to the students who have learned about electricity. The instrument items were analyzed based on the validity, reliability, level of difficulty, distracters, and discriminating power.

3.7.1 Validity

Validity defined as the appropriateness, correctness, meaningfulness of the evidence that supports any inferences from the scores (Fraenkel and Warren, 2012). To measure the validity of the test-items, the researcher uses the formula below:

$$r_{xy} = \frac{N.\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{\{N\Sigma X^2 - (\Sigma X^2)\}\{N.\Sigma Y^2 - (\Sigma Y^2)\}}}$$

(Minium *et al*, 1993)

According to Minium et al (1993), interpretation about coefficient *x* and *y* variable divided into several ratios as shown in Table 3.3

Table 3.3. Interpretation of Validity

Value r	Interpretation

0,80,<r≤1,00	Very High
0,60,<r≤0,80	High
0,40,<r≤0,60	Enough
0,20,<r≤0,40	Low
0,00,<r≤0,20	Very Low

(Minium a, 1993).

3.7.2 Reliability

According to Fraenkel and Warren (2012), reliability refers to the consistency of test result. Reliable here means that a test must rely and fit on several aspects in conducting the test itself. A test should be reliable toward students. To measure the reliability of the test-items, the researcher uses the formula below:

$$K_{21} = \frac{K}{K-1}\ 1 - \frac{M-(K-M)}{SD^2}$$

(Fraenkel and Warren, 2012)

According to Minium et al (1993), interpretation about coefficient *x* and *y* variable is divided into several ratios as shown in Table 3.4

Table 3.4 Interpretation of Reliability

Value r	**Interpretation**
0,80,<r≤1,00	Very High
0,60,<r≤0,80	High
0,40,<r≤0,60	Enough
0,20,<r≤0,40	Low
0,00,<r≤0,20	Very Low

(Minium et al, 1993).

3.7.3 Level of Difficulty

Ebel and Frisbie (1991) states that the difficulty of a test should be a good test is if it has a balance composition between easy and difficult questions that given to the students, means researcher should give optional answer that can be chosen by students

and not far by the key answer. If we wish to calculate the *item difficulty* of a test, we can use the following formula:

$$\text{Level of Difficulty} = \frac{A}{N} \text{x } 100$$

(Cohen et al, 2007)

Where:

A = the number of students who answered the item correctly;

N = the *total* number of students who attempted the item.

The smaller index obtained, the more difficult questions. Otherwise, the greater index gained, the easier question. The difficulty index criteria is shown in Table 3.5

Table 3.5 Level of Difficulty Index

Value	Criteria
0 – 0,29	Difficult
0,30 – 0,69	Medium
0,70 – 1,00	Easy

(Arikunto, 2010)

3.7.4 Distracters

Distractor defined as the distribution of students, as the test object, in choosing the optional answer (distractors) in multiple choice questions (Arikunto, 2010). The number of distractor can be obtained by calculate the number of students in choosing the distractors on the students' answer sheet.

3.7.5 Discriminating Power

Cohen (2007) states that discriminating power refers to the potential of the item in question to be answered correctly by those students who have a lot of the particular quality that the item is designed to measure and to be answered incorrectly by those students who have less of the particular quality that the same item is designed to measure. To measure the reliability of the test-items, the researcher uses the formula below:

$$Dp = \frac{BA}{JA} - \frac{BB}{JB} = P_A - P_B$$

(*Arikunto, 2010*)

Where:

D = Discriminating Power

JA = Amount of high Achiever

JB = Amount of low Achiever

BA = Amount of high achiever who answers question with the right answer

BB = Amount of low achiever who answers question with the right answer

P_A = Proportion of high achiever who answer question with the right answer

P_B = Proportion of low achiever who answer question with the right answer

Table 3.6 shows the discrimination index of the test item.

Table 3.6 Classification of Discrimination Power

D	Classification
0,00 – 0,20	Poor
0,21 – 0,40	Satisfactory
0,41 – 0,70	Good
0,71 – 1,00	Excellent

(Arikunto, 2010)

3.8 Instrument Analysis Result

The instrument for measuring students' STEM Literacy is an objective test in a form of 25 multiple choices. The instrument should be tested in the terms of validity, reliability, discriminating power, and difficulty level as described before. The test was given to 42 students in 10^{th} grade who have learned about the electricity concept. The summary of test item analysis tabulated in Table 3.7 as follows:

Test item recapitulation:

Table 3.7 Recapitulation of Test Item for Students' STEM Literacy

No	DP	Category	DL	Category	Validity	Category	Decision
1	0,27	Satisfactory	0,71	Easy	0,214	Low	Used
2	0,36	Satisfactory	0,61	Medium	0,318	Low	Used
No	**DP**	**Category**	**DL**	**Category**	**Validity**	**Category**	**Decision**
3	0,00	Poor	1	Very Easy	-		Used
4	0,18	Poor	0,43	Medium	0,07	Very Low	Used
5	0,00	Poor	0,09	Very difficult	0,039	Very Low	Revised
6	0,64	Good	0,59	Medium	0,538	Enough	Used
7	0,00	Poor	0,95	Very easy	-0,04	Very Low	Used
8	0,64	Good	0,64	Medium	0,469	Enough	Used
9	0,54	Good	0,5	Medium	0,394	Low	Used
10	0,09	Poor	0,04	Very difficult	0,206	Low	Used
11	0,18	Poor	0,14	Very difficult	0,059	Very Low	Revised
12	0,45	Good	0,83	Easy	0,294	Low	Used
13	0,00	Poor	0,14	Very difficult	0,059	Very Low	Rejected
14	0,27	Satisfactory	0,35	Medium	0,253	Low	Used
15	0,00	Poor	0,69	Medium	-0,06	Very Low	Used

16	0,27	Satisfactory	0,26	Difficult	0,23	Low	Used
17	0,00	Poor	0,47	Medium	0,531	Enough	Used
18	-0,09	Poor	0,07	Very difficult	-0,013	Very Low	Revised
19	-0,27	Poor	0,26	Difficult	-0,254	Very Low	Rejected
20	0,18	Poor	0,92	Very easy	0,228	Low	Used
21	0,64	Good	0,5	Medium	0,588	Enough	Used
No	**DP**	**Category**	**DL**	**Category**	**Validity**	**Category**	**Decision**
22	0,82	Excellent	0,45	Medium	0,725	High	Used
23	0,82	Excellent	0,47	Medium	0,655	High	Used
24	0,27	Satisfactory	0,35	Medium	0,339	Low	Used
25	0,73	Excellent	0,40	Medium	0,632	High	Used
26	0,55	Good	0,69	Medium	0,506	Enough	Used
27	0,36	Satisfactory	0,21	Difficult	0,447	Enough	Used

Reliability test: 0,67 (high degree)

3.9 Data Processing Technique

In this research there are two types of different data which are collected, those are quantitative data and qualitative data. The quantitative data were gained through objective test, while qualitative data were gained through the rubric of observation sheets. The data processing techniques are explained as below:

A. Quantitative Data Processing

The quantitative data of this result obtained from processing the score components below:

a. Score of Test Items

In this research, the score is used to measuring the improvement of students' STEM Literacy. The data are gained from 25 questions of STEM Literacy in electricity concept. For one correct answer, the question have score one and zero for the wrong answer.

b. Calculation of Gain Score and Normalized Gain

After get the data of the test item score, the data are proceed through gain score and normalized score. Gain score of student can be determined by decrease the posttest score and pretest which used to measure the effectiveness of a treatment to increase students' behavior, while normalized gain is used to measure the improvement of student after they conduct the learning treatment (Hake, 1998).

According to Hake (1998), the formula to get gain score:

$$G = S_f - S_i$$

(Hake, 1998)

Where,

G = Gain score

S_f = Posttest score

S_i = Pretest score

Normalized gain score <g> can be determined by this formula:

$$\langle g \rangle = \frac{\%\, G}{\%G_{max}} = \frac{\%Sf - \%Si}{100 - \%Si}$$

(Hake, 1998)

Where,

<g> = normalized gain score

G = Gain score

Gmax = Maximum Gain possible

S_f = Posttest score

S_i = Pretest score

The value of normalized gain which already got can be interpret using Table 3.8:

Table 3.8 Interpretation of Normalized Gain

Value	Classification
$\langle g \rangle \geq 0{,}7$	High
$0{,}7 > \langle g \rangle \geq 0{,}3$	Medium
$\langle g \rangle < 0{,}3$	Low

(Hake, 1998)

B. Qualitative Data Processing

Qualitative data processing is used to gain the data from the observation sheet rubric. In order to gain the result, the researcher calculates the observation sheet result and convert it into the percentage scale. The following formulae is used to convert the raw score into percentage:

$$P = \frac{R}{MS} \times 100\%$$

Where;

P = Percentage

R = Raw score

MS = Maximum Score

The percentage of raw score which already got can be interpret using Table 3.9:

Table 3.9 Interpretation of Percentage

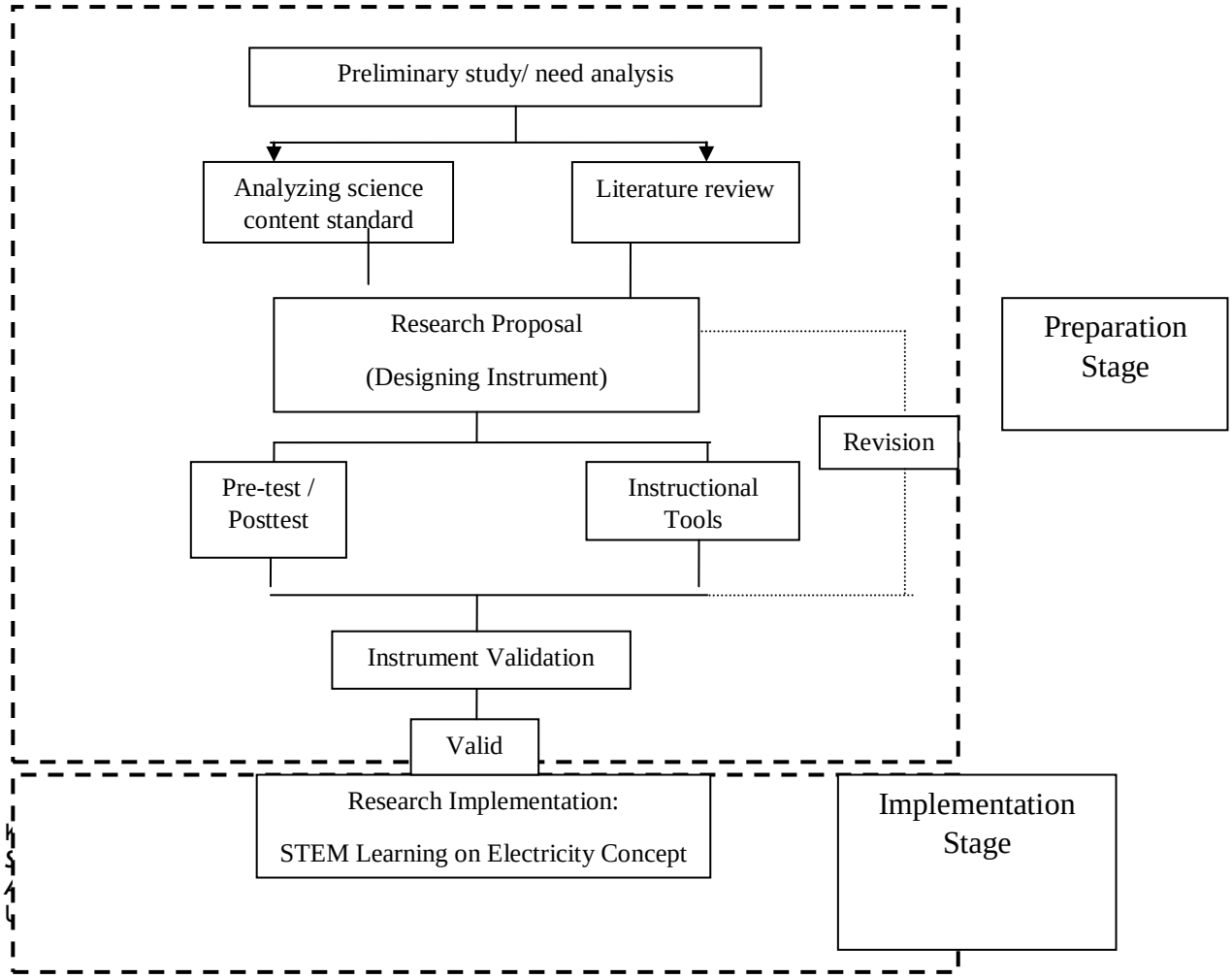
Percentage(%)	Interpretation
80 – 100	Very Good
60 – 80	Good
40 – 60	Moderate

20 – 40	Lack
0 – 20	Very Lack

(Arikunto, 2010).

3.10 Research Procedure

The procedures of research arranged based on the STEM learning implementation. There are three stages of procedure, consist of preparation stage, implementation stages, and completion stage. The research scheme shown in Figure 3.1



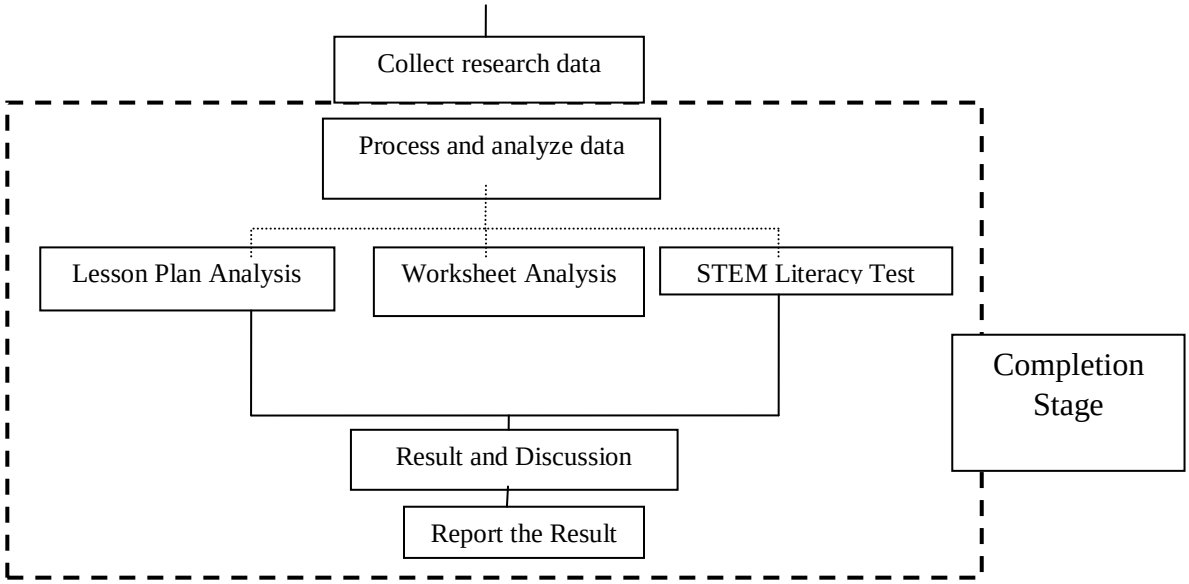


Figure 3.1 Research Procedure

a. Preparation Stage

In this stage, the researcher conduct several steps that support the research, there are:

1) Formulate the problem that will be investigated
2) Determine the focus of variable research
3) Conduct the literature review of STEM Learning, Arduino- Protoboard experiment, and students' STEM literacy
4) Arrange the research proposal which is presented in proposal seminar
5) Revise the research proposal after having suggestions and critics from lecturers
6) Arrange the research instrument and being judged by expert or lecturer
7) Revise the research instrument after having suggestions
8) Try out research instruments

b. Implementation Stage

This stage explains the steps of how research will be implemented which consist of:

1) Determination of class group

2) Giving students pretest to determine students' prior knowledge about electricity concept (electrical circuit, potential different, current, resistance)

3) Giving students pretest to determine students' STEM literacy basic knowledge

4) Processing pretest result

5) Conduct research activity by implementing STEM Learning using Arduino-Protoboard experiment to the class

6) Giving post-test in the sample class to recognize the improvement of students' STEM literacy in sample class

c. Completion Stage

This is the final stage of research procedure, the steps that will be conducted in this research will be explained as the following steps:

1) Analyze the result of the whole research based from the instrument result

2) Discuss and conclude for data analysis result

3) Arrange the report of the research