CHAPTER III
RESEARCH METHODOLOGY

3.1 Research Method and Research Design

3.1.1. Research Method

The research method used in this research was mix method. We used quantitative data and qualitative data Creswell (2014). This research only used one group class as the experimental class. To determine the group experimental class of the research, we considered random technique sampling as the method to get the sample.

3.1.2. Research Design

The design that used in this research is weak experiment. The research used one group pre-test and post-test design as seen in Table 3.1 (Creswell, 2014). We assigns intact only one group as the experimental class, researcher also administers a pre-test and post test to the groups.

Table 3.1 Pre-test and Post-test Design

Pre-test	Treatment	Post-test
O_1	X	O_2

(Source: Arikunto, 2010)

Which is:

O_1 = Observation 1

X   = Treatment of the application of STEM Learning

O_2 = Observation 2

3.2. Population and Sample

The location of this research was an International Junior High School in Bogor. The learning process delivered in english. This school was followed Cambridge International Curriculum modified with Curriculum 2013. The population in this research will be 8th grade students. The samples were one class in eigth grade which consist of 15 students. The group class consists of 7 males students and 8 females students.

The sampling technique was cluster random sampling. Fraenkel and Wallen (2007) stated that cluster random sampling obtained using groups as the sampling unit rather than individuals.

3.3. Operational Definition

In order to avoid misconception about this research. Some operational definitions are explained in this research. Those terminologies are explained as follow:

1. STEM Learning is one of learning model that can be apply in the learning process. STEM learning is the integration of the 4 dicipline. This approach integrate between science, technology, engineering and mathematics in one model. STEM learning that used in this research was according to Jolly (2014). STEM learning have 6 characterics that are:

   a. The focus of STEM learning must be on the real world problems and issues.

   b. Engineering design process is the guide of STEM learning.

   c. STEM learning must consist of hands-on inquiry and open-ended exploration.

   d. Involve students to productive teamwork.

   e. STEM learning apply an exact math and science content based on students learning.

   f. STEM learning allow for multiple right answers and reframe failure as a necessary part of learning.

   The characteristic become the basic to develop the content of activity in STEM learning. Beside that, in order to make the learning well arranged we were use 6 stages of STEM learning according to National Research Council (NRC) to arrange the learning process that can be seen in the Lesson plan. 6 stages of STEM learning that used in this research are:

   a. Asking questions and defining problems

   b. Developing and using models

   c. Planning and carrying out investigation

   d. Analyzing and interpreting data

    e. Using mathematical and computational thingking

    f. Constructing explanations and design solutions

2. STEM Literacy was the outcome of STEM learning approach. Literacy involved in the continuum learning in order to achieved the goals and to developed the potential ability and knowledge to participate fully in the community. STEM literacy specified by scientific literacy, technology literacy, engineering literacy and mathematics literacy. STEM literacy measured by multiple choice questions test that constructed from the definition of STEM literacy based on:

    a. Science Literacy according to National Science Education Standards (1996) was Knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity.

    b. Technology Literacy according to International Society for technology in Education (2000) Ability to demonstrate creativity and innovation, communicate and collaborate, conduct research and use information, think critically, solve problems, make decisions, and use technology effectively and productively.

    c. Engineering literacy according to Organization for economic Cooperation and Development (2003) Ability to systematically and creatively apply scientific and mathematical principles to practical ends such as the design, manufacture,and operation of efficient and economical structures, machines, processes, and systems.

    d. Mathematics literacy according to Program for international Students Assesment (2006) was Capacity to identify, understand, and engage in mathematics, and to make well-founded judgements about the role that mathematics plays in an individual's current and future private life, occupational life, social life with peers and relatives, and life as a constructive, concerned, and reflective citizen.

3. PhET-Arduino based Experiment was the main activity in the STEM learning approach. We used PhET as simulation program before student done

Arduino based experiment. PhET Interactive Simulation is the multimedia learning that developed by University of Colorado. This project build in the 2002 in the form of software. the project consist of the interactive simulation that could be used as the media to learn physics. The simulation are made detail and realistic so it could shows the phenomenon that couldn't be seen by naked eye. While Arduino was the electrical component that could controled the whole electrical circuit that connected. Arduino was in the form of hardware and software. Software of arduino help to add the mathematical equation into the hardware. The mathematical equation control the circuit to works based on the equation. Arduino based experiment use arduino as the main component in the experiment.

4. Electrical Circuit is the materials that learned in this research. The Syllabus of the electricity that applied in the learning process shown in the Table 3.2

Table 3.2 Syllabus of electrical circuit

Standard Competency	Basic Competency	Indicator
4. Understanding the electricity and magnetism	4.2 Understand the electrical quantities and its properties	**4.2.11** use and describe the use of an ammeter **4.2.14** state that the e.m.f. of a source of electrical energy is measured in volts **4.2.16** state that the potential difference across a circuit component is measured in volts **4.2.17** use and describe the use of a voltmeter **4.2.19** recall and use the equation R = V/I

Standard Competency	Basic Competency	Indicator
	4.3 Understand, draw the electric circuits and how to apply them	**4.3.1** draw and interpret circuit diagrams containing sources, switches, resistors, lamps, ammeters voltmeters. **4.3.3** understand that the current at every point in a series circuit is the same **4.3.4** give the combined resistance of two or more resistors in series **4.3.5** state that, for a parallel circuit, the current from the source is larger than the current in each branch.

3.4. Assumption

The assumption as the foundation of this study as follow:

1. STEM education approaches not only increase students' interest but also improves their thinking and practical skill inlearning magnetism, electricity and electrical energy (Anwari, et al, 2015)

2. Engaging studentsin STEM learning activity can increase students achievement in assesment of knowledge and skills of science and math (Kenned & Odell, 2014)

3.5. Hypothesis

Hypothesis that is tested in this study as follow:

H_0 : STEM Learning on electricity using Arduino-PhET based experiment is effective to improve 8th grade students' STEM literacy

Ha : STEM Learning on electricity using Arduino-PhET based experiment is not effective to improve 8th grade students' STEM literacy

3.6. Research instrument

In this research, instrument was necessary to be used for gaining data. Researcher used an objective test as the instrument to achieved and measured student's STEM Literacy on learning electrical circuit. Those instrument was described below.

1. The researcher applied STEM Learning as the approach on the learning activity in the experimental class. The goal of the STEM Learning approach was STEM Literacy. Instrument that used to assess the approach in the learning process can be seen in the lesson plan and also the students' worksheet.

2. In order to measured students' STEM Literacy researcher made an indicator based on the definition of STEM Literacy from some education organization. The definition that used by the researcher to compose the indicator to measure students' STEM Literacy in Zollman (2012) are written below:

   a. Science Literacy according to National Science Education Standards (1996) was Knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity.

   b. Technology Literacy according to International Society for technology in Education (2000) Ability to demonstrate creativity and innovation, communicate and collaborate, conduct research and use information, think critically, solve problems, make decisions, and use technology effectively and productively.

   c. Engineering literacy according to Organization for economic Cooperation and Development (2003) Ability to systematically and creatively apply scientific and mathematical principles to practical ends such as the design, manufacture,and operation of efficient and economical structures, machines, processes, and systems.

   d. Mathematics literacy according to Program for international Students Assesment (2006) was Capacity to identify, understand, and engage in

mathematics, and to make well-founded judgements about the role that mathematics plays in an individual's current and future private life, occupational life, social life with peers and relatives, and life as a constructive, concerned, and reflective citizen.

3.7. Instrument Development

The development of test item needed tomake the test item better. Before use the test item as pre-test and post test to measure students' STEM Literacy, the questions are tested into the another class with the same capacity. After the questions are tested the result is analyze by teacher to find of whether the question are good or need to improved. To improve the quality of the question, we use anatest program.

3.7.1 Instrument Objective Test Requirements

The instrument objective test requirements that used in this research are :

1. Validity

    Validity of the content was the important thing in the multiple choice question. According to the Cohen, Manion & Morrison (2007) The validity of the multiple choice question must showed that it fairly and comprehensively covers the items.

2. Reliability

    According to the Cohen, Manion & Morrison (2007) reliability in quantitative research was synonym for consistency, dependability and replicability over time, instruments and group of respondents. In the quantitave realibility, there're three function of reability. First, Realibility as stability, Reliability as equivalence and reliability as internal consistency. Here in this instrument researcher use the reliability as equivalent. This can be measured through a t-test. Beside that, reliability as equivalent also can be achieved through inter-rater reliability.

3. Difficulty Level

To describe a testee's proficiency in terms of his or her achievement of an item of a known difficulty level. The formula to analyze item difficulty based on Cohen, Manion & Morrison (2007) as follow:

$$P = \frac{A}{N} \, X \, 100$$

P = Difficulty level

A = Number of students who answered the item correctly

N = Total number of students who atttempted the item

(Cohen, Manion & Morrison, 2007)

4. Discriminating Power

When researcher were going to construct the test, researcher need to have an ability to clarify the test item discriminability and item difficulty of each the item of the test. Item Discriminability is patential of the item in question to be answered correctly by those student who have a lot of the particular quality that the item is designed tomeasure and to be answered incorrectly.

$$ID = \frac{Ba}{Ja} - \frac{Bb}{Jb}$$

ID   = Item Discriminating

Ba   = number of high achieving group that have correct answer

Bb   = number of low achieving that have correct answer

Ja   = total participant of high achieving test-takers

Jb   = total participant of low achieving test-takers

(Brown, 2004; Ebel & Frisbie 1991)

To identify the discriminating point can be dertimine using Table 3.2

Table 3.2 Intrepretation of Discriminating Point

Scale	Interpretation
>0.35	Excellent
0.25 – 0.35	Good
0.20 – 0.24	AccepTable
< 0.20	Poor

(Ananthakrishnan, 2000)

5. Distractor

   Distractor according to Cohen, Manion & Morrison (2007) are the stuff of multiple choice item which are incorrect alternatives are offered, and have possibility to make student select the correct alternatives. If the distractor was selected by student many times then it's working effectively, if it's seldom or never selected then it is not working effectively and it should be replaced by another distractor.

3.8. Research Flowchart

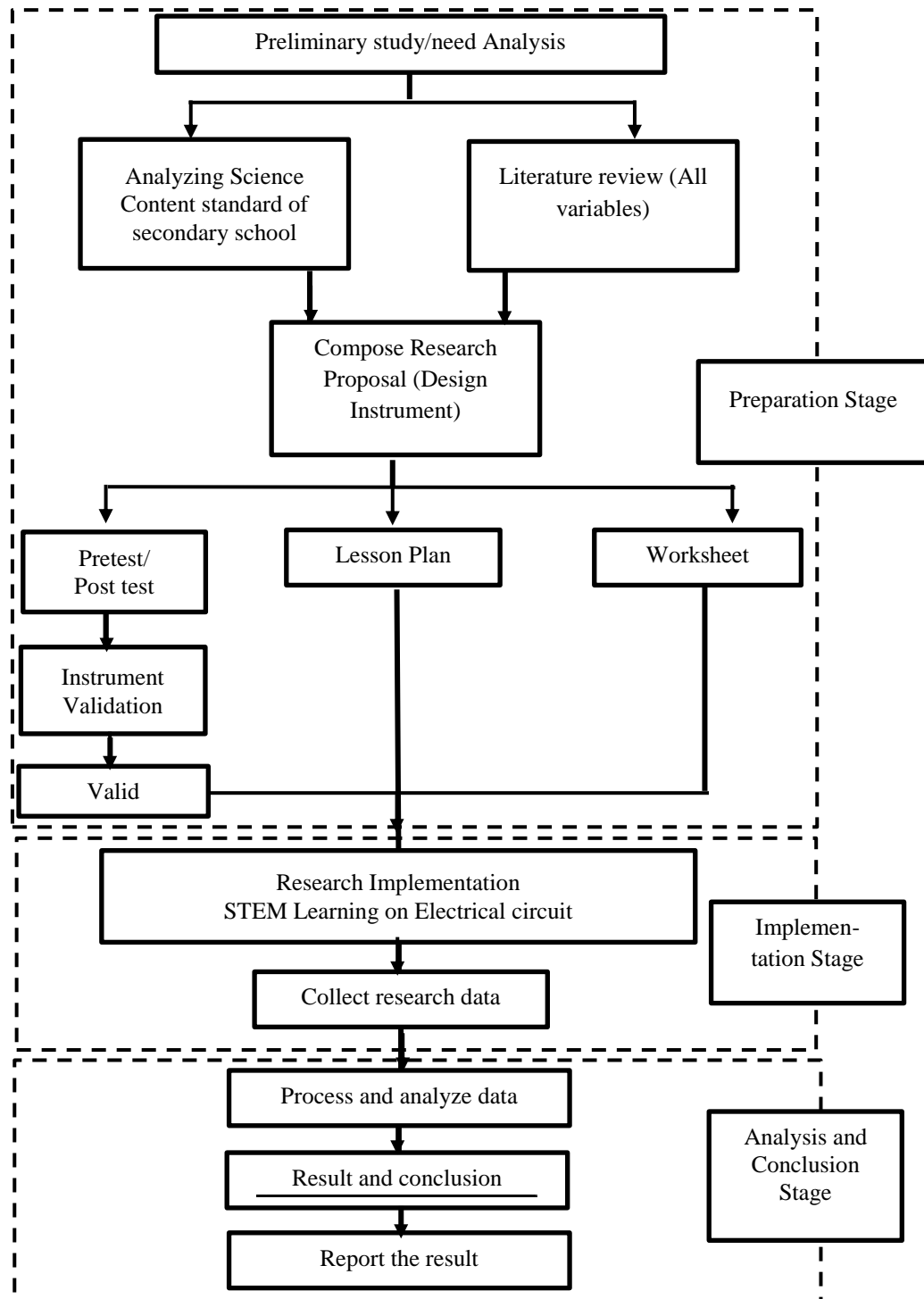The flowchart of the research that conducted is shown in the Figure 3.1

Figure 3.1 Flow Chart Sytematically of Research

3.9. Research Procedure

In order to manage the process of research, we arrange the the research into 3 stages of research. Those stages explained by follows:

3.9.1. Preparation Stage

Preparation stage consist of 13 steps including:

a. Finding the problem for the research.

b. Determine the goal of making the research.

c. Determine the focus of variable research and construct the title of the research.

d. Conduct literature review of STEM Learning, STEM Literacy and Electrical circuit.

e. Analyzing content standard.

f. Arrange the research proposal.

g. Have a consultation to the expert and lecturer.

h. Present research proposal in proposal seminar.

i. Revise research proposal that needed.

j. Arrange research instrument and ask expert to judge it.

k. Revise research instrument that has been judged.

l. Try out research instrument.

m. Revise research instrument based on the result of instrument try out analysis.

3.9.2. Implementation Stage

Implementation stage consist of 5 steps including:

a. Determine the sample that will be used.

b. Give pre-test to the class.

c. Analyze result of pre-test.

d. Conduct research activity by implementing STEM learning approach to the group class.

e. Give post-test the class. The purpose is to gain information of students' STEM literacy.

3.9.3. Completion Stage

Completion stage consist of 4 steps including:

a. Collect the data that has been done in the research as the result.

b. Analyze the result of the research.

c. Discuss and conclude for the data analysis result.

d. Arrange the report of the research.

3.10. Data Collection Technique

STEM literacy consist of 4 aspect of literacy that could be measured. Science literacy, technology literacy, engineering literacy and mathematics literacy are the aspect that including as STEM literacy. We use objective test item to measure 4 aspect of STEM literacy. The objective test consist of 25 questions. The specification of question shows in the Table 3.3

Table 3.3 Test item specification

No	Aspect	Questions item
1	Science literacy	1, 2, 3, 4, 5, 6, 8, 9
2	Technology literacy	7, 10, 11, 12, 13
3	Engineering literacy	14, 15, 16, 17
4	Mathematics literacy	18, 19, 20, 21, 22, 23, 24, 25

After the test item tested, the result are processed by anatest. The recapitulation of the question quality shown in the Table 3.4

Table 3.4 Recapitulation of Test item for STEM literacy

Question Number	Discriminating power (%)	Difficulty Level	Validity	Status
1	45.45	Medium	Validated	Used
2	63.64	Medium	Validated	Used
3	9.09	Very easy	Validated	Revised

Question Number	Discriminating power (%)	Difficulty Level	Validity	Status
4	18.18	Medium	Validated	Revised
5	27.27	Medium	Validated	Revised
6	63.64	Medium	Validated	Used
7	9.09	Very easy	Validated	Revised
8	63.64	Medium	Validated	Used
9	54.55	Medium	Validated	Used
10	27.27	Medium	Validated	Used
11	9.09	Very difficult	Validated	Revised
12	36.36	Very easy	Validated	Used
13	9.09	Medium	Validated	Used
14	-27.27	Medium	Validated	Revised
15	9.09	Difficult	Validated	Used
16	63.64	Medium	Validated	Used
17	0.00	Medium	Validated	Revised
18	18.18	Very easy	Validated	Used
19	0.00	Very difficult	Validated	Used
20	81.82	Medium	Validated	Used
21	81.82	Medium	Validated	Used
22	27.27	Medium	Validated	Used
23	81.82	Medium	Validated	Used
24	63.64	Medium	Validated	Used
25	36.36	difficult	Validated	Used