CHAPTER III
RESEARCH METHODOLOGY

3.1 Research Method and Research Design

1) Research Method

The method of this research is quantitative method. Quantitative is a method for testing objective theories by examining the relationship among variables that can be measured by using instrument to get numbered data which will be analyze statistically (Creswell, 2014). This method is very appropriate to achieve research objectives of this research.

2) Research Design

Quasi experimental design was chosen to know the influence of a treatment in this research. In this design, there are two groups namely experimental and control group. Both groups will be take pre-test and post-test, but only experimental group that conduct a treatment (Creswell, 2014). Experimental group use STEM-engineering design process while control group use conventional learning with the same project in both classes. According to Creswell, the basic intent of an experimental design is to test the impact of a treatment (or an intervention) on an outcome, controlling for all other factors that might influence that outcome (Creswell, 2014). The design of this research is Pretest-Posttest Control Group Design (Creswell, 2014) as shown in the Table 3.1.

Table 3.1
Pretest-Posttest Control Group Design

Experiment Class	O_1	X	O_2
Control Class	O_1	-	O_2

(Creswell, 2014)

Depicted from Table 3.1, O_1 defined as Pre-test and O_2 as Post-test. X indicated the experiment class which implementing STEM-engineering design process while control class use conventional learning. However, to fairly judge between experiment and control class, there is also prototype making during conventional learning in control class.

3.2 Participant

The research's subject is 9th grade students from one of the private school that use Independent Curriculum in Bandung, West Java, Indonesia. The students' age range from 14 to 15 years old and never learn about element, compound, and mixture topic. The sampling method that used in this study is purposive technique sampling because this research use quasi-experiment which needs two classes with the same average score in science. The detail of sample based on gender in both classes are shown in Table 3.2.

Table 3.2
Detail of Research Sample Based on Gender

Gender	Frequency	Percentage
Experiment Class		
Male	11	58%
Female	8	42%
Total	19	100%
Control Class		
Male	13	68%
Female	6	32%
Total	19	100%

3.3 Hypothesis

1) Scientific Literacy

H_0: There is no significant difference in students' scientific literacy post-test between experiment and control class.

H_1: There is significant difference in students' scientific literacy post-test between experiment and control class.

2) Students' Creativity

H_0: There is no significant difference in students' creativity post-test between experiment and control class.

H_1: There is significant difference in students' creativity post-test between experiment and control class.

3.4 Research Instrument

There are two instruments for measuring each of dependent variable of this research. Research instrument that will be used to collect the data as shown in the Table 3.3.

Table 3.3
Research Instrument

No	Data needed	Instrument
1.	Students' Scientific Literacy	20 Multiple Choice Questions of Scientific Literacy Objective Test
2.	Students' Creativity	28 Likert Scale Questionnaire Items of Cognitive Processes Associated with Creativity (CPAC) by Miller (2014)

1) Scientific Literacy Objective Test

The scientific literacy objective test was develop by the researcher based on the material from Independent Curriculum. The topic of this research is element, compound, and mixture with three sub topic that was named the same as the topic, element, compound, and mixture. 20 multiple choice questions consist of competency and knowledge aspect of scientific literacy. According to OECD (2019), the competency aspect consists of explain phenomena scientifically, design and evaluate scientific enquiry, and interpret the data and evidence scientifically. While the knowledge aspect consists of content knowledge, procedural knowledge, and epistemic knowledge. The blueprint of scientific literacy objective test is shown in the Table 3.4.

Table 3.4
Scientific Literacy Objective Test Blueprint

Sub Topic	Explain phenomena scientifically			Design and evaluate scientific enquiry			Interpreting data and evidence scientifically		
	C	P	E	C	P	E	C	P	E
Element	1,3,4				2				5
Compound	7				8		6,9, 10		
Mixture	11,15, 17	18			13,16, 19	14	12		20

(C: Content Knowledge; P: Procedural Knowledge; E: Epistemic Knowledge)

Before used for data collection on research sample, the 20 question items were judge by the expert which can be seen in Appendix A.1 and validated by testing the scientific literacy objective test to 90 students that already learn the element, compound, and mixture topic which can be seen in Appendix A.2. The statistic tests that should be done before question item can be use are validity test, reliability test, discrimination power test, and difficulty level test. By considering all of the results of those, the researcher then take an action such as revised the item that not match the criteria.

Validity test is one of the important test that is done to examine whether the question item is valid or nor. The question item indicated as valid when it can be measure what we want to measure (Sugiyono, 2015). The second test is reliability test which show whether the question is reliable to use or not. The criteria of reliability score by Sugiyono (2013) is presented in Table 3.5.

Table 3.5
The Criteria of Reliability

Reliability	Criteria
0.81 - 1.00	Very High
071 - 0.90	High
0.41 - 0.70	Medium
0.21 - 0.40	Low
0.00 - 0.20	Very Low

(Source: Sugiyono, 2013)

The next statistic test is discrimination power. Discrimination power used to differentiating "upper score student" (students with high score) and "lower class student" (students with low score). A good item is the item that able to discriminate those two kinds of student (Backhoff, Larrazolo & Rosas, 2000). Table 3.6 shows the discrimination power from Backhoff et al. (2000).

Table 3.6
Discrimination Power

Discrimination	Quality	Recommendation
> 0.39	Excellent	Retain
0.30 - 0.39	Good	Possibilities for improvement
0.20 - 0.29	Mediocre	Need to check/review

Discrimination	Quality	Recommendation
0.00 - 0.20	Poor	Discard or review in depth
< -0.01	Worst	Definitely discard

(Source: Backhoff et al, 2000)

The last statistic test is difficulty level test. An item can't be too difficult or even too easy. Difficulty level can define whether the item is good or not by considering its difficulties. The difficulty level from Gronlund (1993) can be shown in Table 3.7.

Table 3.7
Difficulty Level

Difficulty	Quality
P = 0. 00	Too difficult
$0.00 < P \leq 0.30$	Difficult
$0.30 < P \leq 0.70$	Medium
$0.70 < P \leq 1.00$	Easy
P = 1	Too easy

(Source: Gronlund, 1993)

The scientific literacy objective test after undergo the statistical tests before the instrument use to collect the data resulting the conclusion as presented in the Table 3.8.

Table 3.8
Summary of Scientific Literacy Objective Test Analysis

Question Number	Correlation	Discrimination Power	Difficulty Level	Information
1	0.148	Poor	Medium	Revised
2	0.302	Good	Easy	Accepted
3	0.430	Excellent	Easy	Accepted
4	0.439	Excellent	Easy	Accepted
5	0.352	Good	Medium	Accepted
6	0.148	Poor	Medium	Revised
7	0.566	Excellent	Easy	Accepted
8	0.204	Mediocre	Easy	Revised
9	0.446	Excellent	Medium	Accepted
10	0.494	Excellent	Easy	Accepted
11	0.142	Poor	Difficult	Revised
12	0.289	Mediocre	Medium	Accepted
13	0.368	Good	Medium	Accepted
14	0.529	Excellent	Medium	Accepted
15	0.416	Excellent	Easy	Accepted

Question Number	Correlation	Discrimination Power	Difficulty Level	Information
16	0.332	Good	Medium	Accepted
17	0.548	Excellent	Medium	Accepted
18	0.332	Good	Medium	Accepted
19	0.258	Mediocre	Medium	Accepted
20	0.469	Excellent	Easy	Accepted

The reliability score of 20 multiple choice question items of scientific literacy objective test is 0.632 which categorize as medium. By this result, the 20 question items are suitable enough to use in data collecting with some revisions. The final instrument of scientific literacy objective test can be seen in Appendix A.3.

2) Cognitive Processes Associated with Creativity (CPAC)

Cognitive Processes Associated with Creativity (CPAC) is questionnaire item developed by Miller (2014). There are 28 questionnaire items that will be assessed using a 5-point Likert scale ranging from *never* (1) to *always* (5). The instrument may be able to measure both the learning impact of creative abilities and emotional aspects that influence learning satisfaction. All items CPAC questionnaire from Miller (2014). The questionnaire blueprint is shown in the Table 3.9.

Table 3.9
Creativity Questionnaire Blueprint

Domain	Scale				
	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Always (5)
Idea Manipulation					
Imagery/Sensory					
Flow					
Metaphorical/Analogical Thinking					
Idea Generation					
Incubation					

(Source: Miller, 2014)

In the Table 3.9, there are six domain or we can say sub scales that include in creativity questionnaire adapted from Miller (2014). Each sub

scale consist of several item such as idea manipulation consist of 5 items, imager/sensory with 6 items, flow with 4 items, metaphorical/analogical thinking with 4 items, idea generation with 6 items, and incubation with 3 items. The Likert scale aims to know the frequency of students experiencing the things that stated in each item. The ranges of Likert scale start from 1 up to 5 with (1) Never; (2) Rarely; (3) Sometimes; (4) Often; and (5) Always. Likewise scientific literacy objective test, creativity questionnaire also judge by the expert. The expert suggest to make the items easier to understand by elaborate the words with common word that students usually use as can be seen in Appendix A.4. While the revised creativity questionnaire can be seen in Appendix A.5

3.5 Data Collection

1) Students' Scientific Literacy

The 20 multiple choice question items of scientific literacy objective test is spread out through Google Form to make it easier in data collection and scoring. The picture of scientific literacy objective test in google form can be shown in Figure 3.1.

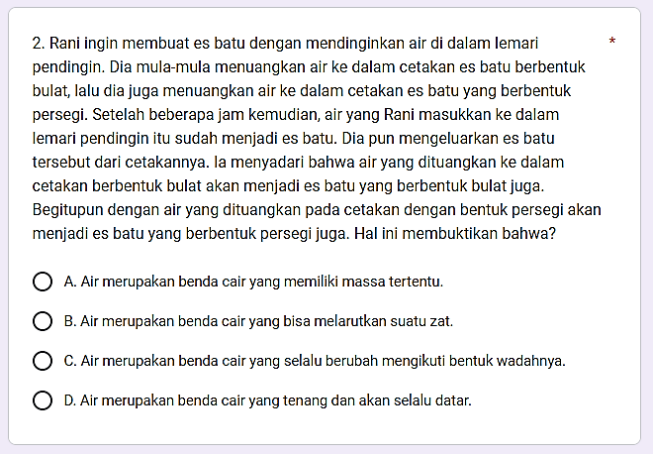

Figure 3.1 Scientific Literacy Objective Test in Google Form

From the Figure 3.1 above, the scientific literacy objective test was served in Indonesian language since the school is not international-based school. But there is one student that needs the question translated into English language due to language barrier.

2) Students' Creativity

The creativity instrument consists of 28 Likert scale questionnaires item and distributed to the students using Google Form as well. The form is different from scientific literacy form since the questionnaire is in the form of Likert scale. The picture of creativity questionnaire is shown in the Figure 3.2.

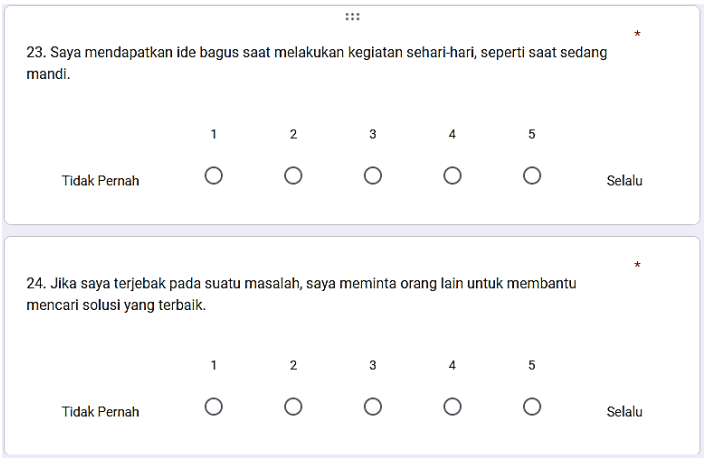

Figure 3.2 Creativity Questionnaire in Google Form

Figure 3.2 is the creativity questionnaire shown in Google Form. As seen above, the item translated into Indonesian language to help students understand the meaning of each item. However the researcher also prepare the original one that is in English language for student who needs it.

3.6 Data Analysis

1) Scientific Literacy Data Analysis

To prove which hypothesis will be accepted, the researcher uses the non-parametric Mann-Whitney test to see if there is a different significance between the experimental class and the control class. However, before conducting a hypothesis test, prerequisite tests such as normality and homogeneity are first carried out using IBM Statistic SPSS 26 to find out whether the research data can be tested parametrically or not. After that, to find out whether there was an increase between the pre-test and post-test values in each class, the N-Gain test was carried out using Ms. Excel. The N-Gain test will also show a comparison of the improvement between the experimental class and the control class. The equation used to calculate N-Gain score is shown below.

$$g = \frac{post\ test\ score - pre\ test\ score}{maximum\ possible\ score - pre\ test\ score} \quad (1)$$

g = N-Gain score

(Meltzer, 2002)

The N-Gain score has categories to describe the data. This category of N-Gain score presented in the Table 3.10.

Table 3.10
N-Gain Score Category

N-Gain Score	Category
$g > 0.3$	Low
$0.3 \leq g \leq 0.7$	Medium
$g > 0.7$	High

The N-Gain category score as shown in Table 3.10 will be used to interpret the N-Gain score so that the researcher can draw a conclusion based on the results.

2) Creativity

The creativity instrument is in the form of Likert scale with ranges from 1 up to 5. After collecting the data, researcher then convert the data in the form of percentage. The equation used is shown below.

$$P = \frac{f}{N} \times 100 \quad (2)$$

With,

P: Percentage

f: Score gained

N: Maximum score

(Source: Riduwan, 2015: 15 from Rockyane & Sukartiningsih, 2018)

The score converted then will be undergo statistic measurement likewise the objective test instrument. The N-Gain score is become the parameter to describe the result of the questionnaire.

3.7 Research Procedure

There are three main procedure in this research namely preparation stage, implementation stage, and completion stage. Each stage will be describe in the follow.

3.5.1 Preparation Stage

Research procedure started with preparation stage in which formulating the research problem. After that, conducting literature review about multiple representation of engineering design process, students' scientific literacy, and students' creative thinking in learning science. The stage is continue with design the instruments which consist of students' scientific literacy and students' creativity. Next, the instrument will be validated by the expert judgement and directly do a revision. After revision, validating the instrument by the students to know whether the instrument can be used or not for the next stages. The last thing to do in this stage is making a lesson plan along with other learning media needed. The lesson plan for experiment and control class can be seen in Appendix B.1 and Appendix B.2 respectively.

3.5.2 Implementation Stage

The second research procedure namely implementation stage which consist of doing the implementation in the class and giving student pre-test and post-test under the permission from the school. The research permit letter can be seen in Appendix C.1. The detail activities of implementation exclude pre-test and post-test in the classroom can be shown in Table 3.11.

Table 3.11
The Implementation Stage of Study

Meetings (Date)	Activities	
	Experiment Class	Control Class
1st Meeting (April 3rd, 2023)	1. Students are given the problem and asked to make a solution based on the problem given. 2. Students defining the problem by understanding the material about element, compound, and mixture. 3. Students looking for the various sources to solve the problem.	1. Students explained about element, compound, and mixture. 2. Students are asked to make water filtration tool.

	4. Students present their initial design based on the implementation of the best solution that they decided.	
2nd Meeting (April 5th, 2023)	1. Students are making the prototype of their tool. 2. Students evaluate the tool (testing the tool based on pH and turbidity) and make final design based on their evaluation.	1. Students are making water filtration tool and test their project based on pH and turbidity.
3rd Meeting (April 7th, 2023)	1. Students collect their report to the researcher. 2. Students make a conclusion of the learning activities that they had done.	1. Students collect their report to the researcher.

3.5.3 Completion Stage

The third one is completion stage, which the researcher collecting and calculating the data for further analyzed the data and find the result. From the result, researcher will continue to make conclusion. The data collected are analyzed statistically and written in the form of research paper. The flow chart of research procedure is shown in the Figure 3.3.

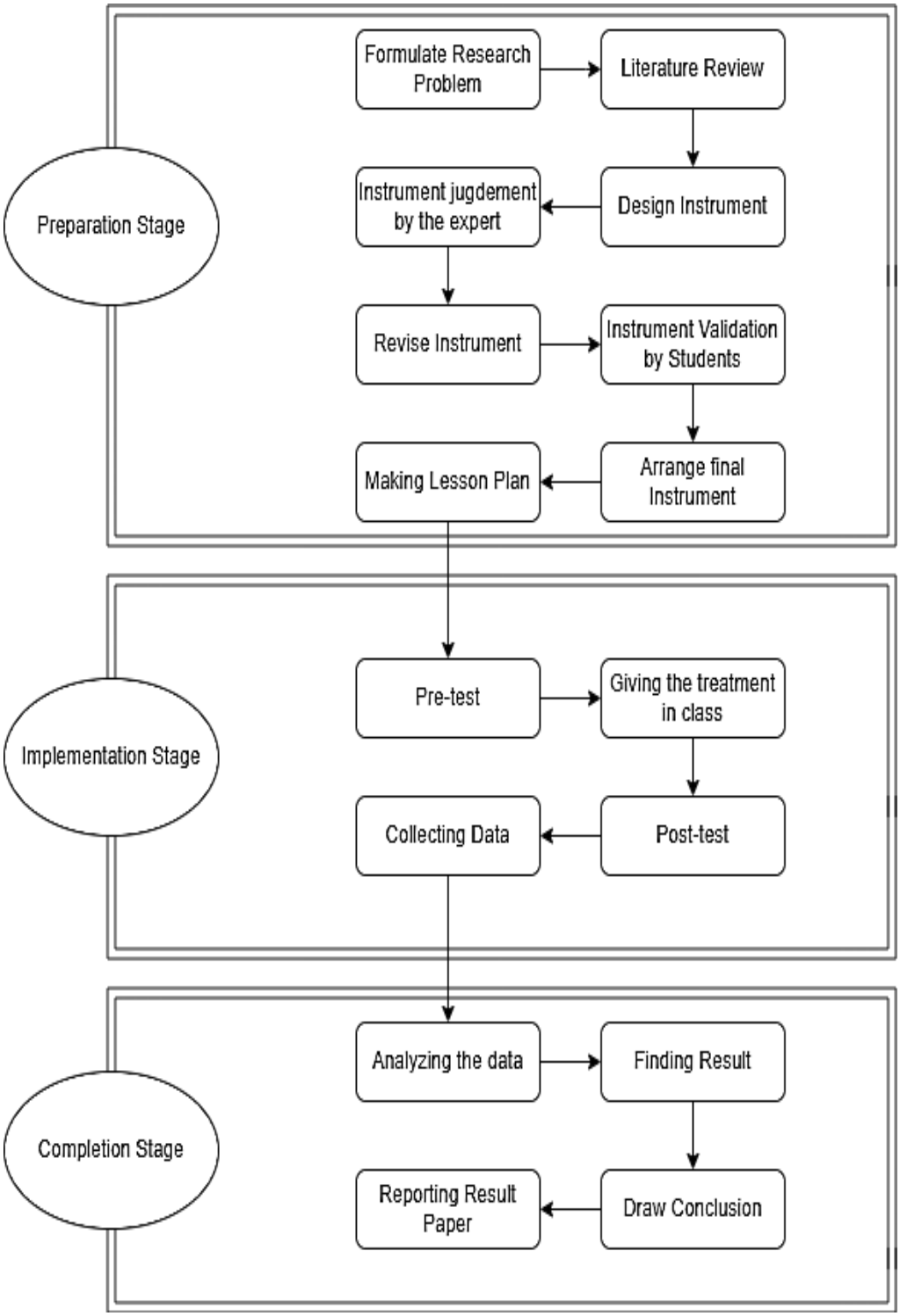

Figure 3.3 Research Procedure Flow Chart