CHAPTER III
RESEARCH METHODOLOGY

3.1 Research Method and Research Design

a) Research Method

This research used quantitative research with pre-experimental methods, pre-post one group design. This method is used to obtain data on the sustainability consciousness and system thinking competency of secondary student before and after the treatment (Creswell, 2014).

b) Research Design

The research used the design of pre-experimental. Pre-experimental also known as a weak experiment design that defined as research that only consists of the experimental group, and does not consider the control group (Fraenkel et al., 2012). The pre-experiment is to give all students the same learning activity. The research used the one group pre-test and post-test design. This design is showed on the Table 3.1

Table 3.1
One Group Pretest-Posttest Design

Pre-test	Experiment	Post-test
O_1	X	O_2

O_1: Pre-test of students' sustainable consciousness and system thinking competency.

X: Implementation of plant modified water filtration as SYEM-based learning

O_2: Post-test of students' sustainable consciousness and system thinking competency.

3.2 Participant and Sample

The participant of this research was grade 7th students in Junior High School that learned using the 2013 Curriculum. The sample of this research was students from grade 7th in Junior High School student that are located in Bandung, West Java. The sample consists of 10 male students and 10 female students. The sample

25

of this research used convenience sampling. Convenience sampling is a type of nonprobability or nonrandom sampling in which members of the target participant meet certain practical criteria, such as ease of accessibility, availability at a particular time, or willingness to participate for research purposes (Etikan, 2016). This sampling is done by taking samples from those who are easy to reach.

3.3 Assumption

a) Plant Modified Water Filtration as STEM-Based learning can enhance the sustainable consciousness of Secondary Students' on the environmental pollution.

b) Plant Modified Water Filtration as STEM-Based learning can enhance the system thinking competency of Secondary Students' on the environmental pollution topic.

3.4 Hypothesis

a) Sustainable Consciousness

1) H0: There is no significant difference between pre-test and post-test after making project of Plant Modified Water Filtration.

2) H1: There is significant difference between pre-test and post-test after making project of Plant Modified Water Filtration.

b) System Thinking Competency

1) H0: There is no significant difference between pre-test and post-test after making project of Plant Modified Water Filtration.

2) H1: There is significant difference between pre-test and post-test after making project of Plant Modified Water Filtration.

3.5 Research Instrument

The research instrument that used in this research is showed in Table 3.2

Table 3.2

The research instruments

No	Data needed	Instrument
1.	Sustainable consciousness	Questionnaire
2.	System thinking competency	Test item

3.5.1 Questionnaire

Sustainable consciousness was measured using Sustainable Consciousness Questionnaire-Short (SCQ-S) that developed by Gericke, et al., (2019) that modified by researcher. The questionnaire consists of 30 items: the environmental dimension is covered by 12 items, the social dimensions by 9 items, and economic dimension by 9 items, each dimension consist three items that belong to the knowingness, attitudes, and behavior aspect. Those aspect are tested on the student who have learned Environmental Pollution Topic. There are four statement of questionnaire which includes to The Strongly agree, Agree, Disagree, and Strongly Disagree. Table 3.3 shows the blueprint of sustainable consciousness before validation.

Table 3.3

Blueprint of sustainable consciousness questionnaire (before validation)

No.	Indicator	Number of Questions			Total Number
		Environmental	Social	Economic	
1.	Knowingness	1, 2, 3	4, 5, 6	7, 8, 9	9
2.	Attitudes	10, 11, 12	13, 14, 15	16, 17, 18	9
3.	Behavior	19, 20, 21, 22, 23, 24	25, 26, 27	28, 29, 30	12
		Total			30

3.5.1.1 Sustainable Consciousness Instrument Analysis

Before being distributed, the instrument was validated by expert judgement by four lectures. The detail result attached in the appendix. Then the instrument was revised and tested student. After getting the results, the test item was asses using the scoring rubric. After measuring the score of pre-test and post-test, the data was analyzed using IBM SPSS to see the validity and reliability.

A. Validity

Validity refers to the accuracy, usefulness, appropriatness, and significance of a given result. Validity is supposed to determine whether the instrument used in research can be truly measure what it is supposed to measure. The interpretation of the validity score is shown in Table 3.4.

Table 3.4
Validity Interpretation

rValue	Interpretation
$r \geq 0.304$	Valid
$r \leq 0.304$	Not Valid

The result of validation analysis of sustainable consciousness questionnaire is presented in Table 3.5.

Table 3.5
Recapitulation of sustainable consciousness questionnaire

Number of Test Item	Validity	Reliability	Conclusion
1	-0.014	0.842	Rejected
2	0.618	0.815	Accepted
3	0.568	0.819	Accepted
4	0.505	0.820	Accepted
5	0.554	0.818	Accepted
6	0.561	0.817	Accepted

Number of Test Item	Validity	Reliability	Conclusion
7	0.447	0.823	Accepted
8	0.725	0.810	Accepted
9	0.406	0.824	Accepted
10	0.466	0.821	Accepted
11	0.520	0.820	Accepted
12	0.629	0.814	Accepted
13	0.584	0.818	Accepted
14	0.718	0.810	Accepted
15	0.133	0.831	Rejected
16	0.462	0.822	Accepted
17	0.434	0.823	Accepted
18	0.136	0.835	Rejected
19	0.469	0.822	Accepted
20	0.569	0.818	Accepted
21	0.587	0.819	Accepted
22	-0.134	0.839	Rejected
23	0.586	0.817	Accepted
24	0.147	0.833	Rejected
25	0.494	0.820	Accepted
26	0.291	0.829	Rejected
27	0.172	0.831	Rejected
28	0.126	0.833	Rejected
29	0.257	0.827	Rejected
30	0.339	0.826	Accepted

After through analysis process using IBM SPSS software obtained the result on the table above. From the recapitulation results was tested to 42 students there are 21 items was accepted and the rest 9 items was rejected. because in the behavior indicators, the test items for social and economic aspects did not meet the criteria, the questions number 26 (social) and 29 (economic) were revised, so that all test items could represent all aspects of the indicator. The blueprint of the sustainable consciousness questionnaire after validation is given in Table 3.6.

Table 3. 6
Blueprint of sustainable consciousness questionnaire (after validation)

No.	Indicator	Number of Questions			Total Number
		Environmental	Social	Economic	
1.	Knowingness	2, 3	4, 5, 6	7, 8, 9	8
2.	Attitudes	10, 11, 12	13, 14	16, 17	7
3.	Behavior	19, 20, 21, 23	25, 26	29, 30	8
	Total	9	7	7	23

3.5.2 Test item

The instrument for measuring System thinking competency will be based on Freiburg heuristic competence. The test item was consist of 24 multiple choice questions which include four dimensions in sub-capability 1, declarative/conceptual systems knowledge, modeling system, solving problems using system models, and evaluation of system models (Riess & Mischo, 2010). All this competence which measured is the manifest achievement in system thinking. This test item is tested in the pretest to know students' prior knowledge and posttest to know the effect after implementation the treatment. The blueprint of the test item before validation is given in the Table 3.7.

Table 3.7
Blueprint of system thinking competency test item (before validation)

Competence Dimensions	Sup-capability	Item number	Number of items
Declarative/Conceptual Knowledge	I: Basic knowledge of system theory (system concepts, system structure, system behaviour, sub-system)	1, 2, 3, 4, 5, 6	6

Competence Dimensions	Sup-capability	Item number	Number of items
Modelling System	I: Determining using system elements, interaction, subsystems, system boundaries, system hierarchies and the model purpose.	7, 8, 9, 10, 11, 12	6
Solving Problems Using System Models	I: Assessing the need of using a system model for processing a present problem	13, 14, 15, 16, 17, 18	6
Dimension 4: Evaluation of System Model	I: Determining the structural validity of system model	19, 20, 21, 22, 23, 24	6
	Total		24

3.5.2.1 System Thinking Instrument Analysis

Before being distributed, the instrument was validated by expert judgement by four lectures. The detail result attached in the appendix. Then the instrument was revised and tested student. After getting the results, the test item was asses using the scoring rubric. After measuring the score of pre-test and post-test, the data was analyzed using Rasch Stacking and Racking to obtain the answers' outfit MNSQ, ZTSD, and Pt. Measure Correlation to see the item fit.

A. Item Fit

Outfit means-square, outfit z-standard, and point measure correlation values are the criteria used to determine item fit. If the three items do not meet the criteria, it can be ascertained that the items are

not good enough so they need to be repaired or replaced. The criteria used to check the appropriateness of items that do not fit (outliers or misfits) are:

1. Accepted value of outfits mean square (MNSQ): $0.5 < MNSQ < 1.5$
2. Accepted value of Z-standard outfits (ZTSD): $-2.0 < ZTSD < +2.0$
3. Value of Point Measure Correlation (Pt Mean Corr): $0.4 < Pt$ Measure Corr < 0.85

(Boone et al., 2014)

The result of item fit analysis is presented in Table 3.8.

Table 3. 8
Recapitulation analysis of system thinking competency

Item Number	OUTFIT		PTMEASURE	Conclusion
	MNSQ	ZTSD	CORR.	
1	0.72	-0.38	0.43	Accepted
2	0.10	-0.70	0.48	Accepted
3	0.68	-0.81	0.50	Accepted
4	0.84	-0.31	0.34	Accepted
5	1.00	0.05	0.38	Accepted
6	0.38	-1.04	0.57	Accepted
7	1.61	0.84	0.26	Accepted
8	1.30	1.59	0.18	Accepted
9	0.93	0.41	0.09	Accepted
10	0.78	-0.24	0.41	Accepted
11	0.84	-0.59	0.44	Accepted
12	1.42	1.80	0.06	Accepted
13	0.65	-1.40	0.58	Accepted
14	3.62	2.31	-0.29	Rejected
15	0.69	-0.77	0.49	Accepted
16	0.83	-0.64	0.49	Accepted
17	1.11	0.53	0.28	Accepted
18	0.50	-0.52	0.48	Accepted
19	1.23	0.73	0.17	Accepted
20	1.12	0.56	0.24	Accepted
21	1.17	0.64	0.26	Accepted
22	1.70	3.60	0.10	Rejected
23	1.11	0.49	0.28	Accepted
24	0.58	-1.60	0.64	Accepted

After through analysis process using Rasch Stacking and Racking obtained the result on the table above. From the recapitulation results was tested to 46 students there are 22 items was accepted and the rest 2 items was rejected. Cronbach's Alpha value on this test item is 0.63 which is included in the "enough" category. While the Person Reliability score was 0.54 and item reliability was 0.89, it can be concluded that the consistency of the students' answers was weak, but the quality of the items in the reliability aspect of the instrument was good. The blueprint of the System thinking test item after validation is given in Table 3.9.

Table 3. 9

Blueprint of system thinking competency test item (after validation)

Competence Dimensions	Sup-capability	Item number	Number of items
Declarative/Conceptual Knowledge	I: Basic knowledge of system theory (system concepts, system structure, system behaviour, sub-system)	1, 2, 3, 4, 5, 6	6
Modelling System	I: Determining using system elements, interaction, subsystems, system boundaries, system hierarchies and the model purpose.	7, 8, 9, 10, 11, 12	6
Solving Problems Using System Models	I: Assessing the need of using a system	13, 15, 16, 17, 18	5

Competence Dimensions	Sup-capability	Item number	Number of items
	model for processing a present problem		
Dimension 4: Evaluation of System Model	I: Determining the structural validity of system model	19, 20, 21, 23, 24	5
	Total		22

3.6 Research Procedure

3.6.1 Preparation Stage

1) Explore the variable with literature study from any sources about topic in this research such as sustainable consciousness, system thinking competency, STEM based ESD learning, and learning material which is about environmental pollution.

2) Identifying problem of sustainable consciousness and system thinking competency.

3) Formulating questions and objectives.

4) Preparing teaching material (media, worksheet, lesson plan, etc.).

5) Make a research instrument (test item and questionnaire).

6) Expert judgement.

3.6.2 Implementation Stage

1) Conduct pre-test of students' sustainable consciousness and system thinking competency.

2) Implementation of water treatment using plant modified.

3) Conduct post-test of students' sustainable consciousness and system thinking competency.

3.6.3 Completion Stage

1) Analyzed the data collected in the form of test item result and questionnaires.

2) Discussion and conclusion based on the result of the analysis.

3) Completing the research paper.
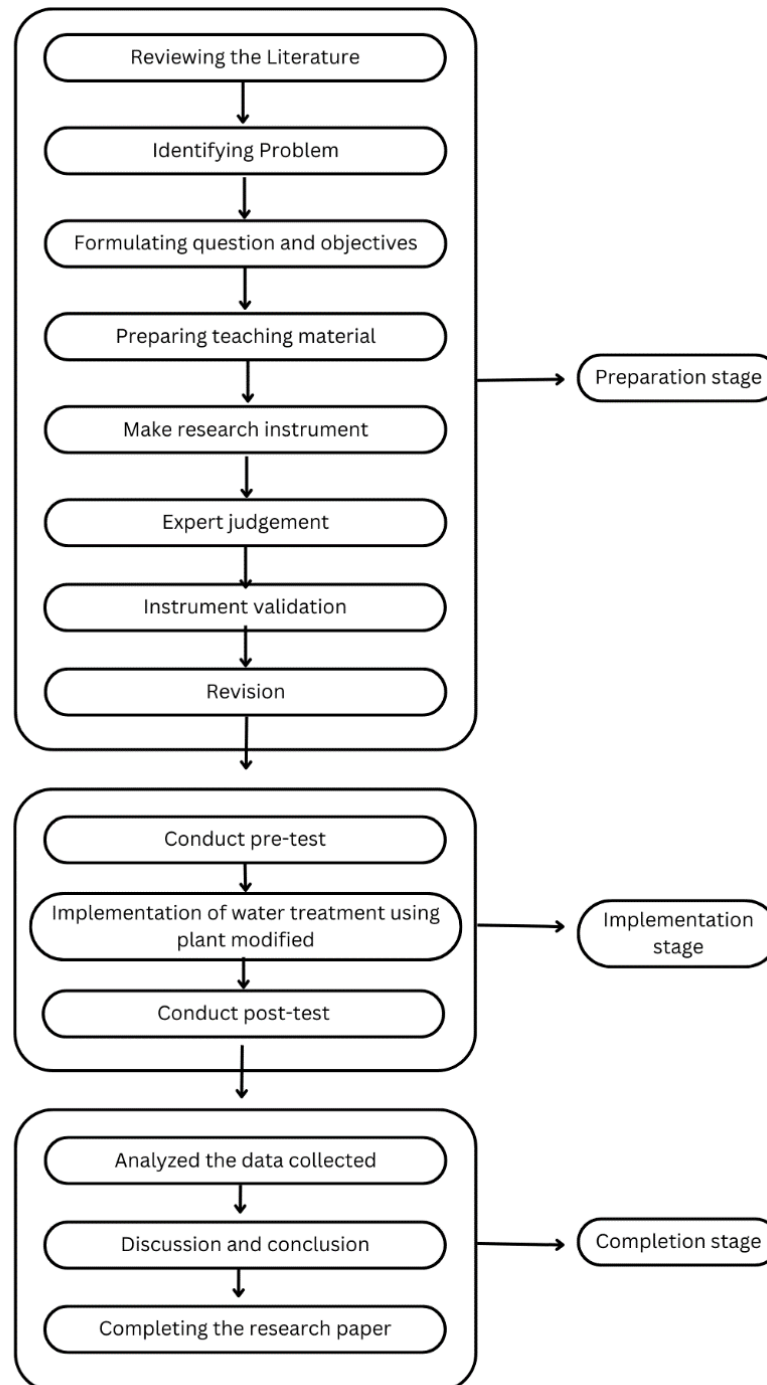
The completion stage of research is shown in Figure 3.1.

Figure 3.1 The completion stage of the research

3.7 Data Analysis of Result

The data resulted in the form of scoring both of sustainable consciousness and system thinking variable. After data is collected, it through several stages analysis using SPSS softwere to determine the hypothesis result. That stages are explained below:

3.7.1 Sustainable consciousness

A. Normality test

The normality test is used to determine whether the obtained data comes from populations that are normally distributed or not. The Saphiro-Wilk test was used because the participant of the research is only 20 participants. The significance level used was α = 0.05. The pretest value is 0.883 and 0.551 for the post-test. because the value were greater than the significance value of 0.005 (p>0.005), so both values were interpreted as normal data distribution.

B. Hyphotesis test

Because the pasrticipant is only 20 students, the next step of analysis was taken using a non-parametric test, namely Wilcoxon signed rank to determine the impact of plant-modified water filtration project as STEM-Based learning regarding the secondary students' sustainable consciousness. The result was 0.045, indicating the hypthotesis is not significance difference. Because Asymp.Sign (2-tailed) values greater 0.005 (>0.00) means H0 is accepted and H1 is rejected.

3.7.2 System thinking competency

A. Normality test

The Saphiro-Wilk test was used because the participant is only consist of 20 students. The significance level used was α = 0.05. The pretest value is 0.049 meanwhile for the post-test value is 0.001. Because the value were less than the significance value of 0.005 (p<0.005), so both values were rejected.

B. Hypothesis test

Because the data from the analysis were not normally distributed, the next step of analysis was taken using non-parametric test, namely Wilcoxon signed-rank test to identify whether there was a difference between the pretest and posttestgiven to the sample. The result shows 0.001 indicating the significance difference. Because the criteria is when Asymp.Sign (2-tailed) value is less than 0.005 (<0.005) means that H0 is rejected and H1 is accepted.

3.7.3 Rasch Stacking and Racking

Rasch stacking and racking is used to analyzed the detailed analysis for each participant. The stages of analysis that must be completed in this research are explained below:

A. Wright Map

Wright Map is a tool that present a visual representation of items, illustrating the difficulty of the questions about the participants' ability. It is also provide the information to camparing the difficulty of each questions (Mary et al., 2010). The display in Wright map will shows mean (M) and two standart deviation points (S and T) for both measured candidate ability and item difficulty. The greater the student's ability indicate the higher their test performance.

B. Scalogram

The graphical of scalogram will present the data matrix in a unique triangular pattern that represent an ideal scale. The analysis of Wright Map data can provide the seriousness of student while answering the questions. It also can provide insights into identifying students' sustainable consciousness and system thinking.