CHAPTER III
RESEARCH METHODOLOGY

3.1 Research Method and Research Design

A pre-experimental method was used in this research. It because designs do not have an integrated control group to compare, since they only have an experimental sample group (Creswell, 2014). Apart from being independent variables several other possible reasons exist for each outcome since the "weak" design has no default controls for a threat to internal validity (Frankael, Wallen, & Hyun, 2012). This method is appropriate with the objective of the research to analyze the impact of STEM-Based Learning on students' problem-solving skills. Thus, the learning process depends on the STEM stages.

The research design used in this research is one group pre-test and post-test. As explained by Frankael, Wallen, and Hyun (2012) the one group pre-test post-test design, the group is assessed or observed not only after treatment but even before. Consequently, the effect of pre-test and post-test can be compared. In general, the research design used can be described as follows in Table 3.1.

Table 3.1

One Group Pre-test Post-Test Design

O	X	O
Pre-Test	Treatment	Post-Test

(Frankael, Wallen, & Hyun, 2012)

Note :

Treatment: STEM-Based Learning

3.2 Population and Sample

The population of the study was students from 7 graders in several schools in the provinces of West Java and Central Java. 33 students were chosen as the sample in this research. The characteristics of the selected students come from the school whose use of the conventional method and have not studied the topic of environmental pollution due to the ineffective online learning at school during this pandemic. However, this research is still restricted to students who are willing to take part in the STEM learning process. Thus, the sampling technique used is convenience sampling.

A convenience sample is the individuals' group who are available or convenient to be studied (Freankel, Wallen, & Hyun). The respondent will continue to search once data from an accessible sample have been collected. The reason for choosing easily accessible samples are needed in this study because STEM learning is applied using an online system and are willing to cooperate with researchers without coercion.

3.3 Research Instrument

In this research, the instrument is necessary to obtain data. There are several types of instruments used in this research. Those instruments are described below;

3.3.1 Problem-Solving Skill

The purpose of this study concerns the disclosure of one aspect of student ability, namely the problem-solving ability of students. Therefore, an objective test is one of the instruments used to measure students' problem-solving skills. The objective test was given to students twice, pre-test, and post-test sessions.

The test will be given in the form of an essay question consist of 7 items with the consideration that aspects will be explored in more depth regarding the problem-solving skill of students. The development of instruments test to be used refers to aspects mentioned in the study of Ghu, Chen, Zhu, and Lin (2015) and OECD (2013). The aspect consists of identifying problems, exploring problems, developing solution, making justification, and evaluation of problem-solving. The following is a blueprint of problem-solving skills which is shown in Table 3.2.

Table 3.2

Essay Test Blueprint

Basic Competence	Aspect of Problem-Solving	Indicator of Competence	Question Number	Amount of Question	Percentage
3.8 *Menganalisi terjadinya pencemaran lingkungan dan dampaknya bagi ekosistem* [Analyzing the occurrence of	Identifying Problem	Identify the problems of environmental pollution	1,2	2	28,56%
	Exploring Problem	Describe the possible causes and effects of the environmental pollution problem	3	1	14,28%

Basic Competence	Aspect of Problem-Solving	Indicator of Competence	Question Number	Amount of Question	Percentage
environmental pollution and impacts on the ecosystem]	Developing Solution	Devise solution to solve the problem os environmental pollution	4,5	2	28,56%
4.8 *Membuat tulisan tentang gagasan penyelesaian masalah pencemaran di lingkungannya berdasarkan hasil pengamatan.* [Writing about the idea of problem-solving related to environmental pollution in their environment based on observations.]	Making Justification	Determine the fit solution related to the problem logically and relevantly according to the evidence/reason for the solution	6	1	14,28%
	Evaluation of Problem-Solving	Evaluate the problem-solving steps of any proposed method	7	1	14,28%
Total				7	100%

Here is the example of a problem-solving skill question and the detailed question can be seen in Appendix 3.

Example of question :

"*Fitoplankton mempunyai peranan penting dalam rantai makanan di perairan dan kelimpahan fitoplankton pada perairan dapat memberikan informasi tentang baik atau tidaknya kondisi kualitas perairan. Jika terjadi ledakan seperti berita diatas, sebutkan beberapa penyebab dari penambahan jumlah (blooming) fitoplankton dan dampak lain yang mungkin terjadi pada aspek lingkungan, kesehatan, dan ekonomi jika permasalahan pada teluk tersebut tidak segera ditangani sesuai dengan hasil analisismu pada teks diatas!*" [Phytoplankton have an important role in the food chain in waters. The abundance of phytoplankton in the waters can provide information about the good or bad condition of the water quality. If there is an explosion like the news above, state some of the causes of the increase in the

number (blooming) of phytoplankton and other impacts that may occur on environmental, health and economic aspects if the problems in the bay are not immediately addressed according to your analysis results in the text above!].

Before measuring students' problem-solving abilities, 7 items of objective test questions were judged by expert lecturers and then tested and analyzed. Item analysis was performed using Anates V4 software. This analysis includes tests of the discriminating power, the level of difficulty, the reliability of the questions, and the validity of the questions.

The instrument was tested on 65 students, 8th-grade students who had studied environmental pollution material. Before going through the validation process, questions consist of 7 questions. Then from the statistical calculations obtained the results of reliability, validity, discriminating power, and the level of difficulty of the questions as presented in Table 3.3. The reliability result obtained 0,85 (very high).

Table 3.3

Test Item Recapitulation

Question Number	Discriminating Power		Difficulty Level		Validity		Status
	Value	Category	Value	Category	Value	Category	
1.	0,37	Satisfactory	0,39	Medium	0,58	Medium	Used
2.	0,37	Satisfactory	0,24	Difficult	0,53	Difficult	Used
3.	0,54	Good	0,55	Medium	0,72	Medium	Used
4.	0,63	Good	0,52	Medium	0,81	Medium	Used
5.	0,57	Good	0,47	Medium	0,79	Medium	Used
6.	0,59	Good	0,55	Medium	0,81	Medium	Used
7.	0,76	Excellent	0,56	Medium	0,84	Medium	Used

After going through several processes, all questions were declared valid. So there is no reduction in the number of questions. Only a few questions have been revised in the choice of words and the diction used based on expert judgment suggestion.

3.3.2 Science Self-Efficacy

To measure students' science self-efficacy in this study, researchers have developed an instrument in the form of a questionnaire which divided into five aspects; identifying problems, exploring problem, developing solution, making justification and evaluation of problem-solving (Lin & Tsai, 2013; Britner & Pajares, 2006). The initial science self-efficacy questionnaire in this research

consists of 28 statements related to the environmental pollution topic. The rating used is 4 points Likert-scale which strongly disagrees, disagree, agree, and strongly agree. The selection of a 4-point Likert scale is intended to negate the middle category of answers that are usually interpreted as not yet able to decide or give an answer or doubt, and to see the tendency of opinion respondents whether they agree or disagree (DuBois & Burns, 1975). Here are the initial blueprint of science self-efficacy instrument which can be seen in Table 3.4

Table 3.4

Science Self-Efficacy Blueprint (Before Revision)

Aspect	Indicator	Question Number	Amount of Question	Percentage
Conceptual Understanding	Identify the participants' ability to use fundamental cognitive skills including concepts, laws, or theories in the domain of science	1,2,3,4	4	14,28%
High Order Cognitive Skill	Evaluates the participants' ability to apply advanced cognitive skills such as problem-solving, critical thinking, or scientific inquiry	5,6,7,8,9	5	17,85%
Everyday Application	Evaluates the ability of students to apply science concepts and related skills to daily life events	10,11,12,13,14,15	6	21,42%
Science Communication	Identify the participant's skills of scientifically communicating or discussing with others	16,17,18,19,20,21	6	21,42%

Aspect	Indicator	Question Number	Amount of Question	Percentage
Physiological State	Identify students' physiological and psychological states such as tension, depression, or anxiety related to science learning	22,23,24,25,26	5	17,85%
Practical Work	Identify students' confidence in their ability to accomplish practical activities included in both the cognitive and psychomotor domains	27,28	2	7,14%
Total			28	100%

Below are shown the example of the statement question of the science self-efficacy questionnaire. The complete inventory could be seen in Appendix 5. *"Saya mengetahui definisi konsep ilmiah dasar (misalnya, polusi lingkungan dan dampaknya terhadap lingkungan) dengan sangat baik".* [I know the definitions of basic scientific concepts (eg, environmental pollution and their impact on the environment) very well].

Before the instrument has gone through various stages. The criteria used in determining the validity of instruments are based on three-component in Rasch Model Analysis which are Outfit Mean Square (MNSQ), Z-Standard Outfit (ZSTD), and Point Measure Correlation (Pt Mean Corr) (Sumintono & Widhiarso, 2014). There are other criteria in the assessment of instrument validity besides the three criteria above, namely the unidimensionality of the instrument. Unidimensionality of the instrument is an essential measure to determine whether the instrument is capable to measure what is expected. In this research, the unidimensionality instruments on self-efficacy instruments get a score of 39,4% and fit into enough category.

The analysis model which was used to process the pilot test data was the Rasch Analysis Model (RAM). The benefits of using the Rasch Analysis model provide a lot of details on each item also the information of the person. Winsteps's Rasch model offers researchers in education or another applied scientific area the most valuable and reliable data for the assessment in products and tests (Törmäkangas, 2011). It is assisted by Winstep 4.4.5. The research used this model to analyze the quality of the test based on validity and reliability. The reliability of Cronbach's alpha value is 0.91. The recapitulation of the instrument is shown in Table 3.5.

Table 3.5

Science Self-Efficacy Recapitulation

Question Number	Outfit MNSQ	Outfit ZSTD	Pt. Measure Corr.	Analysis	Status	New Question Number
1	0,64	-2,03	0,65	Revision	Rejected	-
2	0,90	-0,51	0,68	Valid	Used	1
3	0,92	-0,40	0,51	Valid	Used	2
4	0,90	-0,51	0,68	Valid	Used	3
5	0,93	-0,38	0,57	Valid	Rejected	-
6	0,82	-1,06	0,70	Valid	Used	4
7	1,08	0,51	0,56	Valid	Used	5
8	0,80	-1,07	0,57	Valid	Used	6
9	0,95	-0,22	0,57	Valid	Rejected	-
10	2,08	2,94	0,25	Invalid	Rejected	-
11	1,29	1,49	0,36	Valid	Used	7
12	1,82	4,05	0,09	Invalid	Rejected	-
13	0,61	-2,37	0,64	Revision	Used	8
14	1,85	3,09	0,28	Invalid	Rejected	-
15	1,19	1,05	0,48	Valid	Used	9
16	0,63	-2,31	0,69	Revision	Rejected	-
17	0,61	-2,42	0,66	Valid	Rejected	-
18	1,06	0,41	0,61	Valid	Used	10
19	0,67	-1,95	0,57	Valid	Rejected	-
20	0,71	-1,82	0,62	Valid	Used	11
21	0,70	-1,90	0,60	Valid	Used	12
22	1,21	1,18	0,43	Valid	Used	13
23	1,14	0,83	0,42	Valid	Used	14
24	1,12	0,70	0,57	Valid	Rejected	-
25	0,87	-0,73	0,52	Valid	Used	15
26	1,03	0,21	0,55	Valid	Rejected	-
27	0,92	-0,41	0,56	Valid	Used	16
28	1,01	0,12	0,56	Valid	Used	17

Based on the statistical measurement from 28 items proposed, there are 3 items rejected, 3 items need to revise and the rest of the items could be used as the instrument. But, the distribution of questions should be in a balanced amount. Therefore, even the results of statistical calculations show valid results, but some of these items are not used to measure students' science self-efficacy. Thus, the fixed item used is only 17 statements. The new blueprint after the revision can be seen in Table 3.6.

Table 3.6

Science Self-Efficacy Blueprint (After Revision)

Aspect	Indicator	Question Number	Amount of Question	Percentage
Conceptual Understanding	Identify the participants' ability to use fundamental cognitive skills including concepts, laws, or theories in the domain of science	2,3,4	3	17,64%
High Order Cognitive Skill	Evaluates the participants' ability to apply advanced cognitive skills such as problem-solving, critical thinking, or scientific inquiry	6,7,8	3	17,64%
Everyday Application	Evaluates the ability of students to apply science concepts and related skills to daily life events	11,13,15	3	17,64%
Science Communication	Identify the participant's skills of scientifically communicating or discussing with others	18,20,21	3	17,64%
Physiological State	Identify students' physiological and psychological states such as tension, depression, or anxiety related to science learning	22,23,25	3	17,64%
Practical Work	Identify students' confidence in their ability to	27,28	2	11,76%

Aspect	Indicator	Question Number	Amount of Question	Percentage
	accomplish practical activities included in both the cognitive and psychomotor domains			
	Total		17	100%

3.4 Research Procedure

The research procedures, in general, are divided into three main stages, namely the preparation, implementation, and completion stages. The more detailed procedures regarding each stage are described as follows;

3.4.1 Preparation Stage.

The preparation stage in the form of literature study activities from various sources to find out information about STEM learning, problem-solving skills, and science self-efficacy. Then determine the learning material that is considered appropriate in measuring problem-solving abilities and science self-efficacy. After that, the researcher determines the problem formulation and research questions. The next stage is the process of making a research instrument that consists of essay questions and questionnaires to measure these two variables. Before given to students, the instrument has gone through the stages of expert judgment and test questions to determine the feasibility of the instrument. While waiting for the instrument validation process, researchers are looking for the population to be used by contacting one by one people who are familiar with the 7th graders students. Of the many students in the population, 33 samples were selected according to the criteria described above, especially the ease of access to study in this study. Then, students are starting to the first stage of STEM learning that will be describe below.

3.4.2 Implementation Stage

The implementation stage is a process of data collecting that consists of several steps. The learning process is conducting online. This research was conducted on 28 May – 12 June 2020 depend on each students' schedule because they work independently. The following steps are presented in Table 3.7 for carrying out the research.
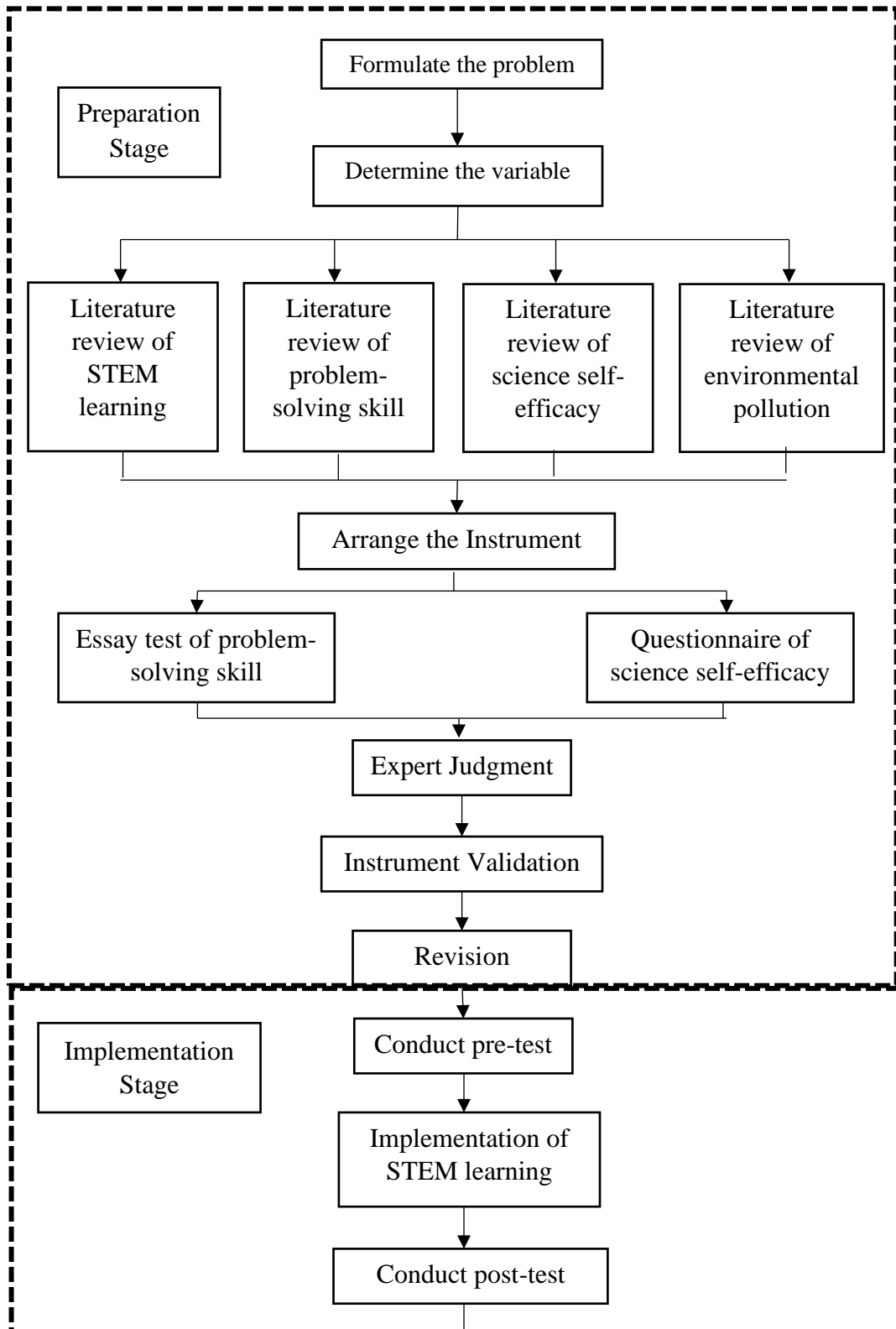
Table 3.7

Implementation Stage

Meetings	The Activities
1st Meeting	1. Students are given directions about learning objectives in a new topic. 2. Students are given a pre-test for both variables which are problem-solving kill essay tests and the questionnaire of science self-efficacy. 3. Students discuss with the teacher about environmental pollution cases they had encountered. 4. Teachers have conveyed the material.
2nd Meeting	1. The teacher guides the students to review the material that has been obtained. 2. Students are given a worksheet by the teacher. 3. The teacher is to guide students to read the text in the worksheet and analyze the cases. 4. Students fill the worksheet based on their knowledge in the idea scoping and idea generation. 5. Students should understand the principles of the product to be made. After that, students choose the material needed and determine the amount of material. 6. Students are trying to design a product to overcome the problem in construct and design stages with any measurement. 7. Then they create a product based on the design that has been created. 8. Students test the products that have been made. 9. Students complete the worksheet. 10. Both teachers and students conclude the activities.
3rd Meeting	1. Students explain the product to the teacher

Meetings	The Activities
	2. Students straighten the principles that should be used and the concepts that students understand.
	3. Students work on post-test questions on problem-solving abilities and science self-efficacy questionnaires.

3.4.3 <u>Completion Stage</u>

After obtaining the required data, the researcher performs data processing using statistical tests which are then analyzed based on theoretical studies to be able to answer questions that have been formulated. Finally, the researcher made conclusions from the results of the data analysis obtained

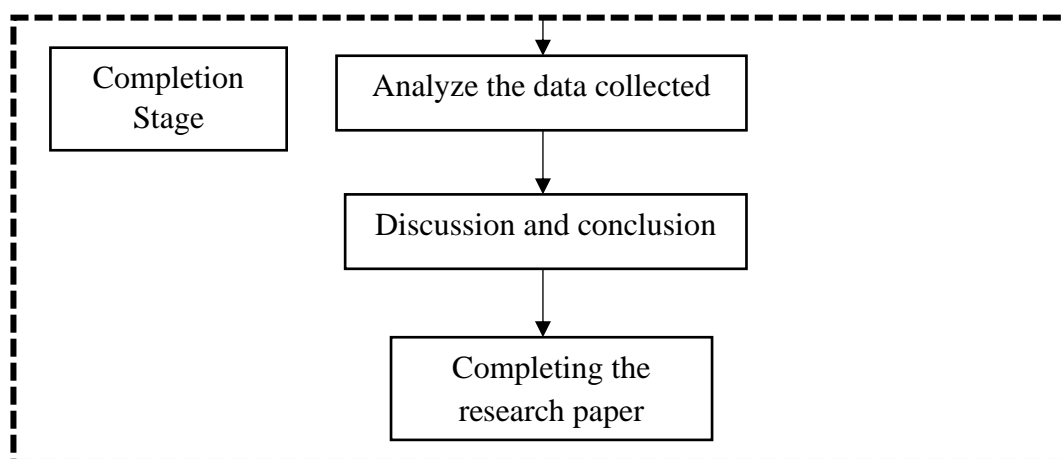All of the process involved in the procedure of research is simplified into the scheme shown in Figure 3.1.

Preparation Stage

Formulate the problem → Determine the variable → Literature review of STEM learning | Literature review of problem-solving skill | Literature review of science self-efficacy | Literature review of environmental pollution → Arrange the Instrument → Essay test of problem-solving skill | Questionnaire of science self-efficacy → Expert Judgment → Instrument Validation → Revision

Implementation Stage

Conduct pre-test → Implementation of STEM learning → Conduct post-test

Figure 3. 1 The Flowchart of Research Procedure

3.5 Data Analysis

3.5.1 Problem-Solving Skill

The results of problem-solving abilities were then analyzed quantitatively, both students' abilities in general and each aspect of problem-solving abilities. There is 7 question which is given to the students to measure the improvement of problem-solving skill. Scoring for pretest and posttest on each item is needed before analyzing deeper. Each question has a score range of 0-3 depending on the given answer by students who have been adjusted to the predetermined answer criteria that can be seen in Appendix 4. So that the maximum score of the students ' result is 21. The scores that have been obtained are then converted from each item to a score (Arikunto, 2009).

The analysis of the results of the problem-solving ability test begins by looking at the answers from the students. The process of assessing student answers refers to the assessment indicators and answer keys that have been made previously which can be seen in Appendix 4. The following describes how to assess one example of student's answers.

1. Tidak berlebihan dalam memberi pakan ikan
2. Tidak berlebihan dalam memberi pupuk
3. Melakukan pengolahan limbah secara mandiri
4. Memilah limbah yang masih bisa digunakan kembali / daur ulang

Figure 3.2 The Problem-Solving Skill Answer

The answers given by students can be seen in Figure 3.2. In this questions, initially the assessment process was seen from the keywords given by the students

and then matched with the keywords listed on the answer keys. Then, from some solutions submitted by students, we should look at how many solutions match the existing keywords. If all the keywords are correct, the number of solutions given in the answer can be calculated. While the student gives more than 3 correct answers, then the student will get point 3. However, if they propose several solutions but there are any keywords are wrong, the student will be given a score according to the correct answer. Although students provide many solutions if all are wrong. They simply will not be assigned any point or get zero points. If all the questions have been given points, then the students' gains from the 7 questions are added up and converted into a score by dividing the points obtained by the maximum points multiplied by 100. The student scores obtained are then processed in a deeper analysis.

Further analysis is using the application of IBM SPSS version 25 which results in the normality, homogeneity, and mean difference test. The results of the actual gain score are obtained that shows the pre-test and post-test difference. The gain score is not enough to describe the increases in the students' experience after following the treatment. Normalize score is a test that can provide a general description of the increase in learning outcomes scores between before (pre) and after (post) the application of the method (Hake, 1998).

A normality test is a test that is shown to determine whether the data comes from populations that are normally distributed. Thus the analysis using the Shapiro-Wilk test. The Shapiro-Wilk test (Shapiro Wilk test) is a highly recommended normality test for small sample sizes (<50) (Ghasemi & Zahediasl, 2012). The interpretation of the Shapiro-Wilk test is that if the significance is below 0.05, the data to be tested has a significant difference from the standard normal data, meaning that the data can be said to be not normally distributed (H_0 accepted).

The homogeneity test aims to determine whether the data value of the problem-solving ability (pre-test and post-test) is homogeneous. The basis for decision making in this test is if the probability or significance value is greater than 0.05 ($p > 0.05$), then the variants of two or more groups are homogeneous (Sudjana, 2005).

The mean difference test calculates a significant disparity between two separate classes between the mean value. It provides an indication, about how much difference there is between the study before giving the treatment and after the treatment. When the data is normally distributed and homogenous, a paired sample T-Test could be used as the statistical measurement.

3.5.2 Science Self-Efficacy

The initial data obtained from students after doing the science self-efficacy is a test score. There are 17 items statement which divided into six aspects. The option is consists of a 4-point Likert scale. Data processing was done qualitatively and quantitatively. Qualitative data were obtained from representations of students as a whole to determine the percentage of student responses who strongly disagreed, agreed, or strongly agreed with the statements given.

Meanwhile, quantitative data is used to determine whether there is an effect of STEM learning on science self-efficacy before and after learning takes place. Before the data is processed using the application, the students' responses are first scored. For the positive statements, a "strongly disagree" is mark 1, "disagree" is mark 2, "agree" is mark 3, and a "strongly agree" is worth 4 marks. While for negative statement 1-point was given for "strongly agree" and 4-point for "strongly disagree". Therefore, the maximum value obtained is 68. The example of positive and negative statements are shown in Figure 3.3 and 3.4.
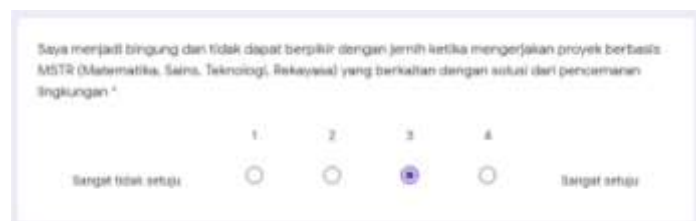

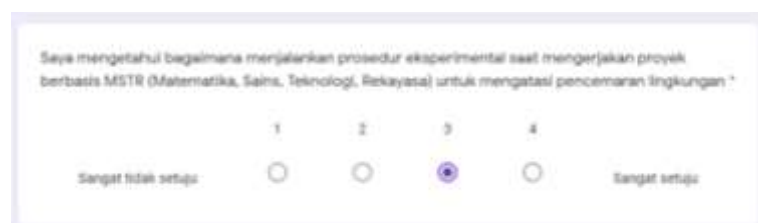Figure 3.3 Negative Statement of Science Self-Efficacy Questionnaire

Figure 3. 4 Positive Statement of Science Self-Efficacy

After the statistical calculations are obtained, it results in the actual gain and normalized gain to represent the treatment impact that has been implemented to the students the standardized benefit score should be determined. The classification of the N-gain percentage is determined using the classification table of science self-efficacy. The range is presented in Table 3.8.

Table 3. 8

Range of Students' Science Self-Efficacy Percentage 4-Point Likert Scale

Range of Achievement (%)	Classification
90-100	Very Good
75-89	Good
65-74	Fairly Good
55-64	Low
0-54	Very Low

(Sudjana, 2008)

Besides that, the normality test is also measured This test aims to determine whether the data value of the science self-efficacy during the pre-test and post-test in the STEM class is normally distributed. Based on the statistical measurement, the probability or significance value is greater than 0.05 ($p > 0.05$), then the data is normally distributed.

While the homogeneity test is used to determine whether the sample used is from a homogeneous population or not. The method used to determine its homogeneity is by comparing the two variances using the IBM SPSS version 25 program.

The last is the mean difference test. This test includes the comparison between both the mean of the pre-test and the post-test to assess whether the result of the two tests is different. When the data is not normally distributed or not homogenous it is possible to use the Wilcoxon test. However, if the data are homogenous or normally distributed, it could use a paired sample T-test.

3.6 Assumption

The assumptions as the foundation of the research are:

1) STEM learning enables students to build their thought in solving any problems in everyday life. Students get a realistic perspective that could be tied together

or implemented in their daily lives. This is also an ability that can improve behaviors, information, comprehension, and conditions of society to build students' belief in science self-efficacy.

2) The science self-efficacy will be achieved if the learners obey the learning process well without missing any further steps.

3.7 Hypothesis

These are the hypotheses tested throughout this research;

H_0: There is no impact on STEM-Based Learning on students' problem-solving skills in learning environmental pollution topic.

H_1: There is an impact on STEM-Based Learning on students' problem-solving skills in learning environmental pollution topic.

H_0: There is no impact on STEM-Based Learning on students' science self-efficacy in learning environmental pollution topic.

H_1: There is an impact on STEM-Based Learning on students' science self-efficacy in learning environmental pollution topic.

3.8 Operational Definition

This study will be clarified to prevent any misunderstandings for any description of the operations. Those things are:

1) STEM-based learning in this research refers to the steps related to the engineering design process which consist of idea scoping, idea generation, construct and design, evaluation of the products constructed. The following steps are written in the worksheet clearly as shown in Appendix 2.

2) Problem-solving skill in this research is the ability of students to overcome the real-life problems specifically on environmental pollution that includes in the aspect of identifying the problem, exploring problem, developing solution, making justification, evaluation. This competence is classified into 7 essay question which is given during the pre and post-test session.

3) Science self-efficacy in this research was measured using 17 items of the questionnaire which were divided into six main aspects that are conceptual understanding, high-order cognitive skill, everyday application, science communication, physiological state, and practical work.