

CHAPTER III

RESEARCH METHODOLOGY

3.1 Research Design

The research method used in this study is the pre-experiment method which uses one group research without the control of the classroom. According to Fraenkel, Wallen, & Hyun (2012), this method has been used to examine the interrelationships within the variables and to analyze extraneous variables that might have influenced the outcome that occurred. This research method is suitable for the purpose of this study, which is investigating the STEM Project-Based Learning as the independent variable towards students' STEM literacy and problem-solving skills as the dependent variable in learning earth layer and disaster topic.

The research design used in this research is one group pre-test post-test. According to Fraenkel, Wallen, & Hyun (2012), in one group pre-test post-test design is able to observe and measure the impact of the treatment not only at the end of the STEM Project-Based Learning treatment but also before the treatment is applied. Therefore, it is possible to compare the result of the pre-test to know their prior knowledge and after the concept given the treatment of the final post-test from one group. The design is as shown in Table 3.1.

Table 3.1
One Group Pre-test Post-test Design

O	X	O
Pre-test	Treatment	Post-test

(Fraenkel, Wallen and Hyun, 2012)

Note:

Treatment = STEM Project Based Learning

3.2 Participant

The characteristics of the chosen schools have been that they apply the 2013 National Curriculum to the learning process. The location where this research carried out is in Bandung City, West Java province. All 7th grade students in Bandung were the population of this study, and 30 students who come from School X are used as the sample. There are 13 male students, and there are 17 females students. The distribution of participants can be seen in Table 3.2.

Convenience sampling is the sampling method used in this research. The sample is taken as the respondents are selected from conveniences and availability. The respondents are continued to be searched by obtaining data from accessible samples until the required sample size has been achieved. Easy access is the main reason why we choose this sampling method (Cohen & Manion, 2001).

Table 3.2
Participant Distributions

Gender	Experiment Class	
	Number of Students	Percentage
Male	13	43.3%
Female	17	56.7%
Total	30	100%

3.3 Research Instrument

The instrument is required in this research in order to be used to collect the data. There are several types of research tools that have been used in this research. Those instruments are described below:

3.3.1 STEM Literacy

An objective test is an instrument that is used to test the students' STEM Literacy, specifically in the earth layer and disaster topic. The same objective test was given to the student as pre-test and post-test. The purpose of the post-test was to measure the improvement of the students' academic achievement. The questions consist of 15 multiple choice questions that cover four aspects of STEM Literacy, science literacy, technology literacy, engineering literacy, and

mathematical literacy. The item constructed based on STEM literacy indicator from Allan Zollman study in 2012. The blueprint of the unrevised and before being analyzed is as shown in Table 3.3.

Table 3.3
Objective Test Blueprint (Before Revision)

Topic and Sub Topic	Aspects of STEM Literacy	Questions	Total	Percentage
<u>Earth layer and Disasters</u>				
1. Earth layers	Science Literacy	1,2,3,4,5	5	20%
2. Volcano				
3. Earthquake and tsunami				
4. Disaster response				
Details:				
1. Observing views or models of the earth's layers	Technology Literacy	6,7,8,9,10	5	20%
2. Gather information about the earth's layers and the mechanism of volcanic eruptions, earthquakes and tsunamis				
3. Present the results of a literature study on mitigating the risks and impacts of natural disasters in the form of presentations				
4. Practicing rescue measures in the event of a natural disaster	Engineering Literacy	11,12,13,14,15	5	20%
	Mathematical Literacy	16,17,18,19,20	5	20%
Total			20	100%

In order to measure students' STEM literacy, an objective test is made to be able to use the objective test in the research, some analysis is required in order to be validated before it can be used as a pre-test or post-test. The curriculum applied in the chosen school is also used as an objective test guideline. After all the items judged by the experts, the objective is then arranged and prepared before being validated and tested to students that have learned the earth layer and disaster topic previously, in this case, are the grade 9 students from 3 classes from the variation of achievements. The validation of the test includes tests such as discriminating power, distractor, and level of difficulty, validity, and reliability using ANATES V4. The validity of the test can be measured by looking at the correlation between the item score and the total score.

Before the objective test for the earth layer and disaster will be used, the objective has to pass multiple checks until it can be considered valid. The objective test was tested on students on higher grade/ other class who studied the topic of earth layer and disaster. The objective test was conducted in this validation on 9th grade students of the same age. After being validated and tested, the analytical evaluation consists of 20 questions. Then the validity, level of difficulty and the discriminating power of the objective test is analyzed. The reliability test shown 0.90, which categorized high. The test was given to graduates of 30 8th grade. The recapitulation of the analysis of the objective test is as shown in Table 3.4.

Table 3.4
Test Item Recapitulation

Question Number	Discriminant Power	Category	Difficulty Level	Category	Validity	Category	Status	New Question Number
1.	0.12	Poor	0.86	Easy	0.28	Low	Rejected	-
2.	0.00	Poor	0.46	Medium	0.11	Very low	Rejected	-
3.	0.75	Excellent	0.73	Easy	0.59	Enough	Used	1
4.	0.50	Good	0.53	Medium	0.41	Enough	Rejected	-
5.	0.62	Good	0.40	Medium	0.49	Enough	Used	2
6.	0.25	Poor	0.83	Easy	0.15	Very low	Rejected	-
7.	0.62	Good	0.76	Easy	0.42	Enough	Used	3
8.	0.75	Excellent	0.50	Medium	0.62	High	Used	4
9.	0.62	Good	0.63	Medium	0.43	Enough	Used	5
10.	0.75	Excellent	0.46	Medium	0.55	Enough	Used	6
11.	0.62	Good	0.70	Medium	0.52	Enough	Used	7
12.	0.75	Excellent	0.33	Medium	0.69	High	Used	8
13.	0.37	Satisfactory	0.63	Medium	0.44	Enough	Used	9
14.	0.62	Good	0.70	Medium	0.52	Enough	Used	10
15.	0.75	Excellent	0.50	Medium	0.52	Enough	Used	11
16.	0.62	Good	0.40	Medium	0.53	Enough	Used	12
17.	0.62	Good	0.53	Medium	0.52	Enough	Used	13
18.	0.50	Good	0.80	Easy	0.46	Enough	Used	14
19.	0.75	Excellent	0.50	Medium	0.55	Enough	Used	15
20.	0.62	Good	0.66	Medium	0.52	Enough	Rejected	-

The test item also receives judgment from many experts as shown in Appendix 5 after being evaluated in terms of validity, reliability, discriminating capacity, and level of difficulty, and then updated in such a way that it is adequate to be used as a research tool for STEM Literacy results. Table 3.5 is the blueprint of the objective test as the research instrument for determining students' STEM Literacy based on the learning objectives and cognitive domain. After having been expertly judged and analyzed by statistical software (ANATES), the results have accepted, revised, or deleted the questions depending on the analysis to be discussed later in the chapter. Out of 20 test items, 15 are used in the research. The new blueprint after the revision is shown in Table 3.5. The detailed recapitulation can be seen in Appendix 6.

Table 3.5
Objective Test Blueprint (After Revision)

Topic and Sub Topic	Aspects of STEM Literacy	Questions	Total	Percentage
<u>Earth layer and Disasters</u>				
1. Earth layers 2. Volcano 3. Earthquake and tsunami 4. Disaster response	Science Literacy	1,2	2	13.33%
Details:				
1. Observing views or models of the earth's layers 2. Gather information about the earth's layers and the mechanism of volcanic eruptions, earthquakes and tsunamis 3. Present the results of a literature study on mitigating the risks and impacts of natural disasters in the form of presentations 4. Practicing rescue measures in the event of a natural disaster	Technology Literacy	3,4,5,6	4	26.67%
	Engineering Literacy	7,8,9,10,11	5	33.33%
	Mathematical Literacy	12,13,14,15	4	26.67%
Total			15	

3.3.1 Problem Solving Skills

In this research, the students' problem-solving skills were measured based on criteria on the Problem Solving Ability test (PSAT) by Chang & Weng (2002). This open-ended essay-question-type method used by the study aimed to test the problem-solving skill of the students in the field of earth science. The questions in the instrument were open-ended to encourage pupils to thoroughly express their opinions and were specifically designed to tap the problem-solving ability of the students. This study entails five open-ended questions. The PSAT was developed and built on the basis of the Creative Problem Solving (CPS) model (Osborn 1963) that emphasizes the convergent (or critical) and divergent (or creative) thinking skills of students in the following four-stage problem-solving processes: fact-finding, problem-finding, idea-finding, and solution-finding (Treffinger and Isaksen, 2005). All questions are adaptive from earthquake problem titled 'BMKG: Jepang Sudah Wajibkan Bangunan Anti Gempa Sejak 1990' in CNN Indonesia reportation (2019). The detailed instrument used can be seen in Appendix 4.

The objective is then arranged and prepared before being validated, judged by the experts, and tested to students that have learned the earth layer and disaster topic previously, in this case, are the grade 9 students from 3 classes. The validation of the test includes validity and reliability test using ANATES V4, shows that the items are reliable with the reliability value (α) = 0.78 and the validity value (r) = 0.63.

Based on the Problem-Solving Ability Test, developed and built on the basis of the Creative Problem Solving (CPS) model, which emphasizes the convergent (or critical) and divergent (or creative) thinking skills of the students, both validity and reliability have been assessed. Consisting with 5 open-ended essay questions. After being judged by experts, Problem Solving Skills subjective test is deemed suitable and therefore undergoes no changes, and so the validity and reliability of the instrument still stand. The final blueprint is as shown in Table 3.6. The detailed recapitulation can be seen in Appendix 6.

Table 3.6
Problem-Solving Skills Subjective Test

Topic and Sub Topic	Problem Solving Skills Aspect	Indicator	Number	Total
<u>Earth layer and Disasters</u>				
1. Earth layers 2. Volcano 3. Earthquake and tsunami 4. Disaster response	Fact Finding	Number and variety of facts identified by the student.	1,2	2
Details:				
1. Observing views or models of the earth's layers 2. Gather information about the earth's layers and the mechanism of volcanic eruptions, earthquakes and tsunamis	Problem Finding	Number of problems recognized by the student and degree of clarity of the problems described by the student.	3	1
3. Present the results of a literature study on mitigating the risks and impacts of natural disasters in the form of presentations				
4. Practicing rescue measures in the event of a natural disaster	Solution Finding	Reasonableness, accuracy, and feasibility of solutions suggested by the student	5	1
Total				5

3.4 Research Procedure

There are three stages in research procedures, which are the preparation stage, implementation stage, and completion stage. The research plot can be seen in the diagram flow below:

1. Preparation Stage
 - a. Problem identification and difficulties experienced by educational bodies in teaching and learning process.
 - b. Decide the investigated specific independent and dependent variables to be in the research.
 - c. Consider several components which will improve the strength of the research such as:
 - 1) The curriculum used in the targeted school, the topic chosen must be appropriate for the variables being investigated.

- 2) Learning instruments that are appropriate to be applied to the students that are based on literature reviews on STEM Literacy and Problem Solving Skills
 - 3) Teaching schedules in the school to plan the lessons that need to be integrated with the treatment.
- d. Identify the research problem and elaborate it into several research questions.
 - e. Formulating several hypotheses for the research.
 - f. Make instruments as tools to gather data, instruments arranged includes an objective test for the pre-test and post-test.
 - g. Construct the lesson plan, presentations, and worksheets that are used as the instructional tools to help the implementation of the treatment.
 - h. Instruments are judged by experts.
 - i. Revise research instruments based on experts' judgments.
 - j. The objective test on the validity, reliability, difficulty level, and discriminating power of the. The trial test is taken by students that have previously learned the earth layer and disaster topic.
 - k. Revise the objective test based on the result of the trial test.
2. Implementation Stage

The implementation of STEM Project-Based Learning is conducted in three meetings. This research was conducted in one of Junior High School in Bandung on 16-30 April 2020 with the sample students from 7th Grade. The learning activities can be seen in Table 3.7 and the complete lesson plan shown in Appendix 1.

Table 3.7

The Implementation of STEM Project-Based Learning

Meeting	STEM Project-Based Learning Stage	Activity
First Meeting	Preparation Stage	Teacher give the student the pretest link to measure the prior student STEM Literacy and problem solving skill 1. Students are introduced to the concept material using video and power point about the earth layer

Meeting	STEM Project-Based Learning Stage	Activity
Second Meeting	Implementation Stage	2. Teacher show the video about the effect of Earthquake in Indonesia
		3. Teacher gives worksheet and the student about the cause of big victim of earthquake in Indonesia
		4. Student analyse the causes of big victim of earthquake in Indonesia
		5. Teacher ask the student to make the project design as the solution from the problem in their home
		1. Students make a project design of Earthquake resistant building (from home)
	Presentation Stage	2. Teacher show the video about Earthquake resistant building
		3. Teacher explain about Earthquake resistant building principle
		4. Teacher asks the student to make the project in their home and report it through the video according to the given worksheet
	Presentation Stage	1. The 10 selected student present their project design via zoom, each student have 5 minutes to present
		2. Other student give feedback about the design
3. Teacher checks student project design and give feedback		
Third Meeting	Evaluation Stage	1. Teacher explain the scoring system about the project
		2. The 5 selected student present their project via zoom, each student have 10 minutes to present
		1. Other student give feedback about the project
		2. Teacher ask the student to give the feedback about the project
		Teacher ask student to fill the post test to measure the student STEM literacy and problem solving skills after the learning activity. The data gaied is analysed.

3. Completion Stage

- a. Analyze the data that has been gathered statistically depending on the type of instrument used for each variable and take further conclusions from the data gathered.
- b. Further discussions are structured based on data analysis and interpretation.
- c. Construct conclusion and recommendation based on the result and discussion.

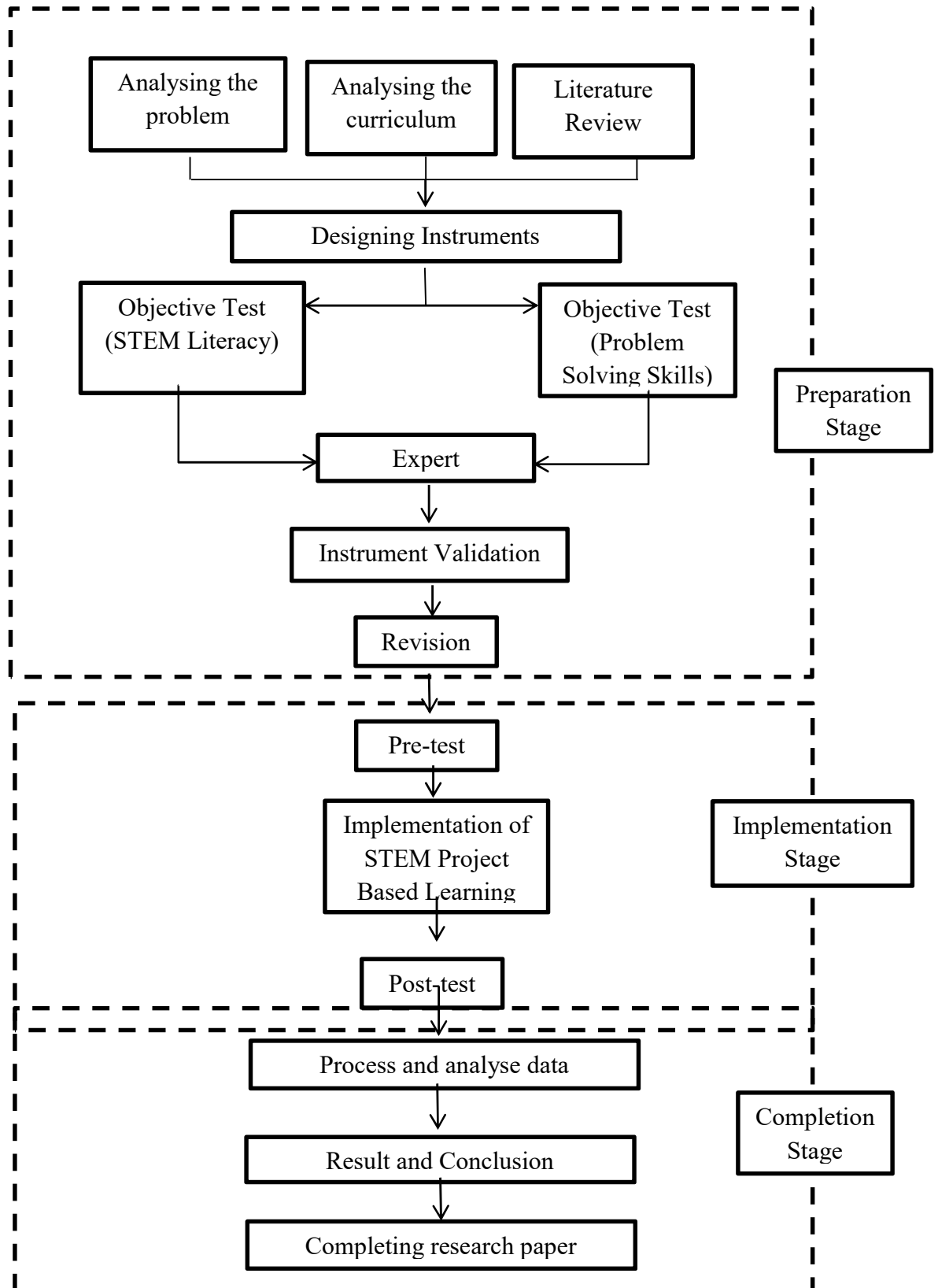


Figure 3.1 The Flowchart of Research Procedure

3.5 Data Analysis

Based on research questions, the data obtained in this study consisted of quantitative data. The steps in processing data from the STEM literacy test and problem solving abilities are described below:

3.5.1 STEM Literacy

Quantitative data in the form of multiple choice question in students' STEM literacy pretest and posttest were then given a score to see the difference. The primary data collected from the academic students' objective test is the test score. The objective test includes 15 questions, and each correct answer for a question is worth 4 marks, while 0 marks would be an incorrect response. Therefore, the results of the students' pretest were obtained in the form of values ranging from 0-60. The steps in processing student STEM literacy test data:

1. Analysis of Pretest Results

The pretest mean scores in the treatment class were calculated, then compared and tested with the mean difference test to determine the difference. The comparison of pretest scores aims to determine the initial conditions of the treatment class that will be used in the study.

2. Posttest Results Analysis

The processing of the posttest scores is the same as the analysis of the pretest results. The posttest scores in both classes were calculated, then tested with the mean difference test. Comparison of posttest scores aims to determine the final conditions in the treatment class after being given learning.

3. Statistical Data Processing

To Further explore how STEM Project-Based Learning gives impact significantly on students' STEM Literacy, the data obtained from the students' pretest and posttest were calculated using a statistical approach. All statistical calculations used in this study used the SPSS version 25.0 application, the data processing consisted of:

a. Normality Test

The normality test is done to determine that the data result is distributed normally or not. The number of students involved was 30 students in each class (less than 50), so the test used was the Shapiro-

Wilk test with a significance level of $\alpha = 0.05$. Based on the results of the normality test on the value of the STEM literacy test, a significance value of 0.053 was obtained for the pretest data and 0.066 for the posttest data, because of the sig value. (P) is bigger than the value 0.05, it can be said that the data are normally distributed. Because of the data is normally distributed, therefore, the data can be analysed with parametric test which is Simple Paired T-test to determine the significance of the STEM Project-Based Learning effect on STEM Literacy. Before conducting the test, Homogeneity test must be done as the requirements.

b. Homogeneity Test

The homogeneity test was conducted to determine the variance of the pretest and post-test data. The homogeneity test in this study used the Levene test with a significance level of $\alpha = 0.05$. If the homogeneity test results are $\text{sig.} > \alpha$ then the data is homogeneous. The test criteria are that the data is homogeneous if the P value (Sig) > 0.05 , while the data is not homogeneous if the P value (Sig) < 0.05 (Sudjana, 2005). From the results of the homogeneity test carried out, the STEM literacy pretest and posttest data has a significance value greater than the $\alpha = 0.05$, which is 0.123 so that the data has a homogeneous variance.

c. Mean Difference Test

Mean Difference Test is a measure of the mean between the pre-test, and the post-test and will decide if the score of the two tests is different. Because of the data is normally distributed and also homogeneous, a paired T-test should be sufficient. Before running the procedure, this kind of test requires assumptions in form of hypothesis. A null hypothesis (H_0) is that there is no difference in mean scores between pre-test and post-test. Meanwhile, alternative hypothesis (H_A) is there is difference in mean scores between pre-test and post-test. Based on the outputs of Paired Samples Test, significance value (2-tailed) is 0.000 and it is less than 0.05 as

explained beforehand. Thus, the null hypothesis (H_0) is rejected and alternative hypothesis (H_A) is accepted. The interpretation is that there is difference between mean scores of pre-test and post-test.

d. Calculation of Normalized Gain Score

After getting the significance status of STEM Project-Based Learning implementation, the researcher also determines to explore Normalized Gain (N-gain) of data as it indicates the effectively of treatment in one group pre-test post-test research. N-gain score test is done by calculating the pre-test and post-test scores. N-gain score gained is 0.47 which in the range of $0.3 \leq \text{N-gain score} \leq 0.7$ and the category is medium improvement based on the Hake (1998) criteria.

3.5.2 Problem Solving Skills

Students' Problem Solving Skills pretest and posttest were then given a score to see the difference in the form of essay question as quantitative data. There are 5 items in the subjective test. As for Problem Solving Skills, that has four components to be measured. Each component has different total marks. The most suitable answer is worth 4 marks, the suitable answer get 3 marks, while quite suitable worth 2 marks, whereas a not related answer will obtain 1 marks with 20 being the highest total mark. The steps in processing student Problem-Solving Skills test data are:

1. Analysis of Pretest Results

The students' pre-test results were obtained as values ranging from 0-100. The mean pretest scores in the treatment class were calculated, then compared and tested to determine the difference using the mean differential test. The comparison of pretest scores aims to determine the initial treatment class conditions to be used in the study.

2. Posttest Results Analysis

The interpretation of the posttest scores is similar to the pretest results analysis. For both groups the posttest scores were determined and then checked with the mean differential test. The aim of comparing posttest scores is to decide the final conditions in the treatment class after instruction is given.

3. Statistical Data Processing

To further investigate how STEM Project-Based Learning has a major effect on the problem-solving skills of students, a statistical approach has been used to measure the data derived from the pretest and posttest of students. The statistical analyses used in this analysis used the program SPSS version 25.0, the processing of data consisted of:

a. Normality Test

To determine that the data result is distributed normally or not, the normality test is completed. The number of students elaborate was 30 students in each class (less than 50), so the test used was the Shapiro-Wilk test with a significance level of $\alpha = 0.05$. Based on the results of the normality test on the value of the Problem-Solving skills test, because of the sig value. (P) is bigger than the value 0.05, a significance value gained is 0.345 for the pretest data and 0.114 for the posttest data, it can be said that the data are normally distributed. The data can be analysed with parametric test which is Simple Paired T-test due to the data is normally distributed. Before conducting the test, Homogeneity test must be done as the requirements.

b. Homogeneity Test

The homogeneity test was conducted to determine the variance of the pretest and post-test data. The homogeneity test in this study used the Levene test with a significance level of $\alpha = 0.05$. If the homogeneity test results are sig.> A then the data is homogeneous. The test criteria are that the data is homogeneous if the P value (Sig)> 0.05, while the data is not homogeneous if the P value (Sig) <0.05 (Sudjana, 2005). From the results of the homogeneity test carried out, the STEM literacy pretest and posttest data has a significance value greater than the $\alpha = 0.05$, which is 0.043 so that the data has a homogeneous variance.

c. Mean Difference Test

Mean Difference Test is a measure of the mean between the pre-test which the post-test, and will decide if the two tests score is

different. A paired T-test should be appropriate, since the data is normally distributed and therefore homogeneous. This type of test includes assumptions in the form of a hypothesis before implementing the procedure. A null hypothesis (H_0) is that there is no difference in mean scores between pre-test and post-test. Meanwhile, alternative hypothesis (H_A) is there is difference in mean scores between pre-test and post-test. According to the outputs of Paired Samples Test, significance value (2-tailed) is 0.000 and it is less than 0.05 as explained beforehand. Thus, the null hypothesis (H_0) is rejected and alternative hypothesis (H_A) is accepted. The interpretation is that there is difference between mean scores of pre-test and post-test.

d. Calculation of Normalized Gain Score

After obtaining the significance status of implementation of STEM Project-Based Learning, the researcher also decides to investigate Normalized Gain (N-gain) of data as it suggests the efficacy of treatment in one category of post-test testing. The N-gain score test is performed by calculating the scores pre- and post-test. N-gain score gained is 0.73 which in the range of $0.7 \leq \text{N-gain score} \leq 1$ and the category is high improvement based on the Hake (1998) criteria

3.6 Assumption

The assumptions as the foundation of this research are as follow.

1. STEM Project-Based Learning model considered students' Capacity to control and regulate facets of their learning, such as perception, behaviour, environment, and input on learning outcomes.
2. Students' STEM Literacy is considered one of the importance of competences that have to be attained by the students.
3. Problem Solving Skills will be developed seriously in this learning activity by doing a project.

3.7 Hypothesis

The hypothesis that is tested in this research is as follows.

H₀: There is no effect on students' STEM Literacy in learning earth layer and disaster using STEM Project-Based Learning.

H₁: There is an effect on students' STEM Literacy in learning earth layer and disaster using STEM Project-Based Learning

H₀: There is no effect on students' Problem Solving Skills in learning earth layer and disaster using STEM Project-Based Learning.

H₁: There is an effect on students' Problem Solving Skills in learning earth layer and disaster using STEM Project-Based Learning.

3.8 Operational Definition

An operational definition is given in this research in order to avoid misconceptions, and those terminologies are expressed as followed:

1. STEM Project-Based Learning is applied to students based on the lesson plan as shown in Appendix 1. As stated by Capraro, et al., (2013) STEM Project-Based Learning is more relevant in interdisciplinary learning as it obviously requires several different skills, such as reading, writing, mathematics and aids in the creation of intellectual knowledge by assimilating many different subjects as their opportunity to live in society and solve the STEM-related issue of daily life. Parallel with Tseng et al. (2013) revealed that STEM Project-Based Learning could enhance the learning motivation of students, create meaningful learning, help students solve the problem of daily life, and support future careers. Also suitable for building STEM literacy, which is now recognized as an important educational outcome for all students
2. Students' STEM Literacy in this research is the competence of students consists of competencies, skills, and knowledge. STEM literacy will enable the students to compete in a new knowledge-based economic era, according to Zollman (2012) consists of Scientific Literacy, technological literacy, Engineering Literacy, and Mathematical Literacy. This competence was measured using an objective test that consisted 15 multiple-choice questions (pre-test and post-test).

3. Students' Problem-Solving Skills in this research was measured using 5 open-ended essay questions based on Problem Solving Ability test developed based on Creative Problem Solving (CPS) Model, emphasizes on student's convergent and divergent thinking skills within the following four-stage problem-solving processes, such as fact-finding, problem-finding, idea-finding, and solution-finding. This test is already judged by experts.
4. Earth Layer and Disaster are chosen as the topic that is learned in this research. The topic focused on four subtopics based on National Curriculum 2013 syllabus, which are the Earth layer, Volcano, Earthquake, and tsunami, also the disaster response.