CHAPTER III
RESEARCH METHODOLOGY

3.1 Research Method and Design

Research requires a certain method and design in order to achieve the desired outcome, which will support the enrichment of knowledge and the science learning process. The research method and research design used in the implementation of the research are explained below.

3.1.1 Research Method

The research method used is a quasi-experimental method to establish a cause-and-effect relationship (White & Sabarwal, 2014). This type of experimental research allows researchers to assign the participants, but not randomly because they cannot create groups for the experiment by themselves (Creswell, 2008). The main objective of this research is to explore the use of digital mind map as the tool for enhancing students' computational thinking in learning about global warming.

3.1.2 Research Design

The research design for this study is a pre-post-test design. This design allows researchers to investigate the differences in scores gained due to the treatments from pre-post-test results towards experimental and control groups (Cohen, Manion, 2017). The pretest is given to gain information about the student's prior knowledge. After different treatment is given to both groups, a posttest is assigned to find out whether or not there are expected changes in certain knowledge and skills (Faenkel et al., 2012). The Table 3.1 below shows how the research is designed.

Table 3.1
Quasi Experimental Pretest and Posttest Design

Groups	Pre-Test	Treatment	Posttest
Control Class	O_1		O_2
Experimental Class	O_1	X (Digital Mind Map)	O_2

3.1.3 Treatment Procedure

The implementation of this research was done in three meetings on experimental class and two meetings on control class. Due to the COVID-19

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outbreak, the implementation was fully conducted online. All of the participants got their pretest done on the first meeting and posttest on the last meeting. Each meeting was run for 60 minutes on regular days and 45 minutes during Ramadhan days. The teaching-learning method that was used is problem-based learning. The syntax was spread among the two and three meetings. The treatment procedure or learning activities can be seen in Table 3.2 below.

Table 3.2
Treatment Procedure

PBL Stages	Experimental Class	Control Class
Orientate the problem	**Meeting 1** A pretest was given. Then, students watched a news video about the impact of global warming around the world as stimulation. Then, questions were given to orientate the problems. The introduction and concepts about Global Warming were also given, explained, and discussed through Genially.	**Meeting 1** A pretest was given. Then, students watched a news video about the impact of global warming around the world as stimulation. Then, questions were given to orientate the problems. The introduction and concepts about Global Warming were also given, explained, and discussed through Genially.
Organize the students	**Meeting 1** Students were introduced to the digital mind mapping platform and the example of applying CT in science issues. Students were asked to solve a set of Global Warming problems by using the CT concept and creating digital mindmap at the next meeting.	**Meeting 1** Students were introduced to computational thinking and the example of applying CT in science issues through the CT module.
Guiding the Research	**Meeting 2** Another news video and news article that reports about global warming impacts were given. Students had to process the information as a part of abstraction, decomposition, and pattern recognition to create their first digital mindmap. The DMM consist of the definition, causes, and effects of global warming.	**Meeting 1** Another news video and news article that reports about global warming impacts were given and asked to be solved. Students had to process the information as a part of abstraction, decomposition, and pattern recognition to create their first digital mindmap. The mind map consists of the definition, causes, and effects of global warming. Volunteer students were asked to present their works.
Develop & present the works	**Meeting 3** Students created the second DMM that consists of ways to prevent global warming based on the impacts or problems presented in the previous meeting as a part of algorithm thinking. Volunteer students were asked to present their DMM.	**Meeting 2** Students created the second mind map that consists of ways to prevent global warming based on the impacts or problems presented in the previous meeting as a part of algorithm thinking. Volunteer students were asked to present their mind maps.
Analyze & evaluate	**Meeting 3** Teacher clarify students' concept and conclude the topic. Posttest of CT skill in global warming topic was given.	**Meeting 2** Teacher clarify students' concept and conclude the topic. Posttest of CT skill in global warming topic was given.

3.2 Population and Sample

The population of this research was the 7th-grade students with a total of 44 students in 2 classes at one of the private junior high schools in Bandung that uses the 2013 National Curriculum. The sampling technique of this research is purposive sampling where there is an effort to choose certain types of a representative sample from a population (Ross, 2005). The chosen classes should meet two characteristics which are having average score of 78 or above on science midterm test score and having average score of 80 or above on their activities point. One class was chosen as the experimental class, while the other one was chosen as control class. Those two classes were expected to be able to cooperate well with the researcher without any cognitive barrier. The same cognitive level of those two classes can be seen through the evidence of their average final and midterm test score on science that are above the other three classes. After the learning process done, there are only 30 students that followed all of the experiment implementation's procedures.

3.3 Operational Definition

To avoid any misconception about this research, the operational definitions are stated. The research variables are as followed:

1) Digital mind map is a digitally created mind map by using a computerized tool. Students used Creately to digitally visualize their computational thinking, comprehension and ideas about the topic by following computational thinking-based digital mind map module as a guidance.
2) Computational thinking difference between experimental and control class was gained by statistically compare their pretest score, then their posttest score. An analysis also conducted to see the enhancement from pretest to posttest in each class. The scoring was gained from students' score in answering 10 essay questions of computational thinking on global warming.
3) Global Warming is a teaching and learning material for 7th grade based on the 2013 National Curriculum. The sub-topics include the greenhouse effect, global warming process, factors and impacts of global warming, and ways to overcome global warming. The materials were taught by using

computational thinking strategy to dominantly solving global warming problems.

3.4 Assumption

In this research, the assumptions based on literacy study and experts mentioned as follows:

1) Digital mind map could help students in visualizing thoughts and information during the learning process, replacing the paper-based mind map that more takes time and wastes papers.
2) Computational thinking is a process and concept of problem-solving ability that is one of the 21st century's important skills. Here the computational thinking is expressed in the form of digital mind map.

3.5 Hypothesis

The hypothesis that would be tested in this study are as following:

a. H_0: There is no difference in students' computational thinking between control class and experimental class in learning global warming by creating digital mind map.

   H_1: There is a difference in students' computational thinking between control class and experimental class in learning global warming by creating digital mind map.

b. H_0: There is no correlation between students' mind map score and students' computational thinking score.

   H_1: There is a correlation between students' mind map score and students' computational thinking score.

3.6 Research Instrument

Research instruments in this study are used to measure students' mind mapping ability and students' computational thinking in learning about global warming. Below are the instruments that used in this research shown on Table 3.3.

Table 3.3
Research Instruments

No.	Instrument	Data Obtained
1.	Computational Thinking Test	Students' Computational Thinking
2.	Mind Map Evaluation Rubric	Students' mind mapping ability

Further description of the instruments described as follows:

3.6.1 Computational Thinking Test

Computational thinking test in this research is a set of essays about the global warming concept to measure students' computational thinking skills. Four aspects of computational thinking, which are decomposition (DC), abstraction (AB), pattern recognition (PR), and algorithm (AL) are included in this test. The subtopic on global warming is divided into 5 parts. The unrevised blueprint of computational thinking test items on global warming topic is shown in Table 3.4.

Table 3.4
Blueprint of Computational Thinking Test
(Before Revision)

No.	Subtopics	Computational Thinking Aspects			
		DC	AB	PR	AL
1	Greenhouse effect		1	1	2
2	The impacts of global warming	9, 10	9	10	6
3	Global warming process		4	8	8
4	The greenhouse gasses	3	3		
5	Overcoming global warming				5, 7, 11

This test item was firstly judged by three experts and then validated by testing it on students that have already learned about global warming which is filled by 30 students of 8th graders from various Junior High School. To find out its validity, reliability, difficulty level, and discrimination power, the test validation score from students were analyzed by using ANATES V4.

1) Validity

The validity of the test is represented in the correlation between item score and total score. Essay validity instrument calculated by the coefficient formula product-moment by Karl Pearson as follow:

$$Rxy=\frac{N\Sigma xy-(\Sigma x)(\Sigma y)}{\sqrt{\{N\Sigma x^2-(\Sigma x)^2\}\{N\Sigma y^2-(\Sigma y\}^2}}$$

(Kaplan & Saccuzzo, 2013)

The validity criteria are used in the Table 3.5 below:

Table 3.5
Validity Classification

Correlation coefficient	Reliability category
0.80-1.00	Very high

0.60-0.79	High
0.40-0.59	Average
020-0.39	Low
0.00-0.19	Very low

(Kaplan & Saccuzzo, 2013)

2) Reliability

Reliability refers to the consistency of an instrument, or in this research is the test items. A high level of reliability shows that the test would provide permanent results if repeatedly tested. Below is the formula to measure the reliability of the essay instrument.

$$r11=\left(\frac{n}{n-1}\right)\left(1-\frac{\Sigma\sigma_i^2}{\sigma_i^2}\right)$$

(Ali et al., 2016)

Description

r11 : reliability test

n : the number of items

$\Sigma\sigma_i^2$: the number of score variance of items

σ_i^2 : total variance

The reliability criteria that are used follows the Table 3.6 below:

Table 3.6
Reliability Classification

Correlation coefficient	Reliability category
0.80-1.00	Very high
0.60-0.79	High
0.40-0.59	Average
0.20-0.39	Low
0.00-0.19	Very low

(Ali et al., 2016)

3) Discrimination Power

The discrimination power of a test item is the ability of the question to distinguish between high achievers and low achievers students. The higher the discrimination power, the higher the ability to distinguish clever students and less clever ones. The following formula is used to determine the discriminating power of a test item.

$$D=\frac{B_A}{J_A}-\frac{B_B}{J_B}=P_A-P_B$$

(Brown et al., 2004)

4) Difficulty Level

To measure the level of difficulty for essay question, difficulty level test conducted by following this formula:

$$P = \frac{Mean}{Maximum\ Score}$$

(Zulaiha, 2008)

Then, the difficulty index level is categorized in the following table below:

Table 3.7
Difficulty Level Categorization

Difficulty Level	Test Item Category
0.00-0.30	Difficult
0.31-0.70	Average
0.71-1.00	Easy

(Zulaiha, 2008)

After being analyzed, it is calculated that the item reliability score is 0.86 which is categorized as very high. Below is the recapitulation of test items analysis by using ANATES V4.

Table 3.8
Recapitulation Analysis of Computational Thinking Test

Question Number	Discriminating Power (%)	Difficulty Level	Correlation	Significance Correlation	Acceptance	New Question Number
1	45.83	Medium	0.737	Very Significant	Accepted	1
2	50.00	Easy	0.577	Significant	Rejected	-
3	70.83	Medium	0.773	Very Significant	Accepted	2
4	45.83	Medium	0.541	Significant	Accepted	3
5	62.50	Medium	0.645	Very Significant	Accepted	4
6	62.50	Medium	0.796	Very Significant	Accepted	5
7	41.67	Medium	0.635	Very Significant	Accepted	6
8	45.83	Medium	0.578	Significant	Accepted	7
9	33.33	Medium	0.486	Significant	Revised	8
10	45.83	Medium	0.585	Significant	Accepted	9
11	62.50	Medium	0.809	Very Significant	Accepted	10

Considering the experts' suggestions, competencies domain, and computational thinking aspects distribution, the test items are revised. The final test items resulted to be used are reduced into 10 essay questions with

recapitulation as followed. The detail is attached to Appendix A.2. Table 3.9 below shows the blueprint of the test items after revision.

Table 3.9
Blueprint of Computational Thinking Test
(After Revision)

No.	Subtopics	Computational Thinking Aspects			
		DC	AB	PR	AL
1	Greenhouse effect and global warming process		3	1, 7	
2	The greenhouse gases		8	9	5
4	The impacts of global warming	2			
5	Overcoming global warming	10			4, 6

3.6.2 Mind Map Evaluation Rubric

A rubric is used to measure students' mind mapping ability through creating both paper and digital mind map. The rubric is adapted from the University of Minnesota and McGraw-Hill mind map scoring rubric. The details of the rubric blueprint are shown in Table 3.10

Table 3.10
Blueprint of Mind Mapping Rubric

Mindmap Criteria	Level 1	Level 2	Level 3	Level 4
Content	• At least has 2 causes and 2 effects of global warming • Unspecific ideas about preventing glob al warming	• At least has 3 causes and 3 effects of global warming • At least has 2 ideas of global warming prevention	• At least has 4 causes and 4 effects of global warming • At least has 3 ideas of global warming prevention • Include the idea of sustainable energy to reduce the effect of global warming	• At least has 5 causes and 5 effects of global warming • At least has 4 ideas of global warming prevention • Include the idea of reducing greenhouse gasses emission • Include the idea of sustainable energy to reduce the effect of global warming
Connection	• Ideas are not connected from the most complex to simplest • No use of color, codes, or links to show	• Some ideas move from the most complex to simplest • Some effort to use color, codes, or links to show	• Ideas are arranged in order of importance from the most complex to simplest • Uses color, codes, or links	• Clear and highly effective indication of a connection between ideas and central image • Effective use of color, codes, or

	connections between ideas • Limited or ineffective effort to connect main ideas	connections between ideas • Good or adequate effort to connect main ideas	to show connections between ideas • Effective effort to connect main ideas	links to make connections between ideas meaningful • Highly effective effort to connect main ideas
Communication	• Use common sentences rather than keywords • Low understanding of the topic	• Use keywords but still use long sentences • Average understanding of the topic	• Good use of keywords and images connected to the central topic. • Good understanding of the topic	• Highly effective use of keywords and images • Deep understanding of the topic
Organization	• Choppy and confusing • Inappropriate structure	• Somewhat organized • A non-linear structure that shows some relationships between ideas	• Thoughtfully organized • A non-linear structure that provides a picture of the ideas • Follows the standard map conventions	• Well organized • Logical format • A non-linear structure that provides a complete picture of the ideas • Follows standard map conventions

(Minnesota, 2004; McGraw-Hill, 2008)

3.7 Data Analysis

The result of this research is gathered by a qualitative approach. The data were gained from students' pretest and posttest that measures students' computational thinking and mind map rubric that measures students' mind mapping ability. The result will describe whether there is an improvement in students' computational thinking. Below is a further explanation of the data analysis.

3.7.1 Students' Computational Thinking

Students' computational thinking is analyzed from students' answers during pretest and posttest. The test item consists of 10 questions with the maximum score for each question is 3, resulting in 30 as the maximum score for the test. The data from students' scores is explained below.

1) Normality and Homogeneity Test

Normality and homogeneity test was conducted using SPSS 25. The normality test is done to see whether or not the data is normally distributed. Referencing the significant value of Shapiro-Wilk, if the significance is ≥

0.05, the data is normally distributed. Also for the homogeneity test, if the significance value is ≥ 0.05, then the data is considered to be homogenous.

2) Normalized Gain

In order to find the enhancement of students' computational thinking score from pretest to posttest, a normalized gain (N-gain) score is calculated. The N-gain was calculated using the formula below.

$$\text{N-gain} = \frac{Posttest\ score - pretest\ score}{Maximal\ score - pretest\ score}$$

(Hake, 1999)

After the N-gain score is obtained, the result is categorized into:

Table 3.11
N-Gain Categorization

N-gain Score	Category
N-gain > 0.7	High
0.7 ≥ N-gain ≥ 0.3	Medium
N-gain < 0.3	Low

(Hake, 1999)

3) Independent T-Test and Mann-Whitney Test

The next step after taking the normality and homogeneity test is testing the hypothesis. An Independent T-test is conducted after the data is considered to be normally distributed and homogenous, meanwhile a Mann-Whitney test is conducted if the data is not normally distributed. SPSS 25 is used to find the significance, if the result of level significance (sig) ≤ 0.05 means H_0 rejected then if (sig) > 0.05 means H_0 accepted.

3.7.2 Students' Mind Maps

A rubric is used to measure students' mind mapping ability. Students' mind map was scored based on the rubric, then the score was analyzed using Microsoft Excel 2013. To calculate the percentage of students' mind mapping ability, the formula follows:

$$P = \frac{R}{MS} \text{ x } 100\ \%$$

(Arikunto, 2013)

Description:

P : Percentage

R : Raw Score

MS : Maximum Score

Then, the result from percentage calculation is categorized into certain category as:

Table 3.12
Interpretation of Percentage Formulation

Percentage (100%)	Category
80 – 100%	Very Good
66 – 79%	Good
56 – 65%	Enough
40 – 55%	Lack
<40%	Very Lack

(Arikunto, 2013)

After that, in order to see the correlation between the mind map score and students' computational thinking score, Pearson's correlation coefficient was used. Below is the interpretation of the correlation value in Table 3.13.

Table 3.13
Pearson Correlation Coefficient Interpretation

Size of Correlation	Interpretation
0.90 to 1.00 (-0.90 to -1.00	Very Strong Correlation
0.70 to 0.89 (-0.70 to -0.89)	Strong Correlation
0.40 to 0.69 (-0.40 to -0.69)	Moderate Correlation
0.20 to 0.39 (-0.20 to -0.39)	Weak Correlation
0.00 to 0.19 (0.00 to -0.19)	Very Weak Correlation

(Schober & Schwarte, 2018)

3.8 Research Procedure

This study is arranged into three stages following the order of systematic research. The three arrangements include the preparation stage, implementation stage, and completion stage.

a. Preparation Stage

Here are several steps to support the preparation stage of the research:

1) Identifying research problems
2) Formulating research objectives
3) Conducting literature review on students' computational thinking, digital mind map, and Global Warming topic.
4) Arranging research instruments and asking for expert judgment.
5) Revising research instruments that have been judged by the experts.

6) Validating research instruments to the experts and non-sample students.

b. Implementation Stage

The steps of the implementation stage consist of:

1) Determination of control and experimental class.
2) Give pretest to the control and experimental class to gain information students' computational thinking ability in Global Warming topic.
3) Analyze pretest results.
4) Conduct research activities by implementing digital mind mapping in the experimental class, manual mind mapping in the control class, and introduction to computational thinking in solving science issues in both of the classes.
5) Analyze digital and manual mind map results.
6) Give posttest to control and experimental class to picture students' computational thinking in Global Warming topic after the activities are done.

c. Completion Stage

After all the data are obtained and gathered, the stage is continued to:

1) Analyzing the data gained from the research.
2) Discussing findings resulted from the data.
3) Drawing conclusion from the data analysis results.