CHAPTER III

RESEARCH METHODOLOGY

3.1 Research Design

The research design used in this research is survey research. It is procedure in quantitative research in which investigators administer a survey to a sample or to the entire population of people to describe the attitudes, opinions, behaviors, or characteristics of the population. Different from experimental research, survey research do not involve a treatment given to participants by the researcher (Creswell, 2012). This is in accordance with the purpose of this research that is to diagnosed students' conception on Heat topic. There was no intervention made in this research, the researcher just portray students' conception as what it is.

The cross-sectional type of survey design is used in this research. In cross-sectional survey design, the information is collected at just one point in time although the time it takes to collect all of the data may take anywhere from a day to a few weeks or more (Fraenkel, Wallen, & Hyun, 2011). In this research, the questions consist of four-tier test on Heat topic and two open-ended questions are administered online to the sample using Google Form. This instrument can measure the level of students' conception and also reveal students' misconceptions. The data is then collected for about three weeks. From the data collected, researcher analyzed the data and interpret it to map students' conception on Heat topic.

3.2 Participant

Participants who involved in this research were students of lower secondary schools. Students' characteristics for being the participants were students who have already learned about heat topic under 2013 National Curriculum. All seventh grade students in Bandung City, West Java Province were the population of this research. There are 125 students participated that consist of 59 male and 66 female students with an age range of 13-14 years old. The participant came from two private schools and one public school. The distribution of the participants can be seen in Table 3.1

Convenience sampling is used in this research. It is done by taking samples from those who are easy to reach (Wu & Thompson, 2020). 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. This sampling method is very suitable for this research because this research needs lot of participants and has a limited time.

Table 3.1

Participant Distribution

Gender	Number of Students	Percentage (%)
Male	59	47.2
Female	66	52.8
Total	125	100

3.3 Operational Definition

1. Students' Conception

Students' conception is students' beliefs, theories, meanings, and explanations that they develop throughout their experience both inside and outside schools. Students' conception that involved in this study consist of five level that is adapted from previous researches (Caleon & Subramaniam, 2010; Gurel et al., 2015; Kiray & Simsek, 2021) which are scientific knowledge, false positive, false negative, misconception, and lack of knowledge. Students' conception level is diagnosed using four-tier test.

2. Misconception

Students' misconception is when students' conceptions are not in line with scientific facts agreed by experts. This is diagnosed when students provide wrong answer and reason but confident in their answers to the questions.

3. Four-Tier Test

A four-tier diagnostic test is an instrument used to measure students' conception that consists of four tiers which are the main question, the confidence level for the main question, the reason, and the confidence level for the reason. There are four options for the first and third tiers. Meanwhile, for the second and the third tiers there are two options that are sure and not sure. The combination of students' answers on each question were coded as a sequence and then analyzed based on rubric that is adapted from the previous research (Kiray & Simsek, 2021).

3.4 Research Instrument

The instrument is needed to collect data from the participant. In this research, a four-tier diagnostic test on Heat topic is developed from several researches. The developed instrument is used to diagnose students' conception on this topic. There are 20 sets of questions constructed. There are two subtopics which are the nature of heat, and heat transfer. Each subtopic contains three different concepts. The distribution and the concepts of the questions can be seen in Table 3.2.

Table 3.2

Question Distribution

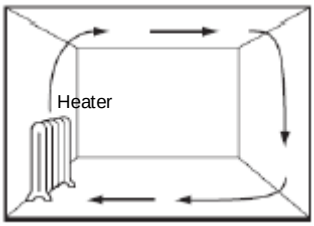
Topic	Sub-topic	Concept	Test Item
Heat	Nature of Heat	Characteristic of Heat	1, 2
		Heat and temperature of an object	3, 4, 5, 6
		Heat and change of state of matter	7, 8
	Heat Transfer	Conduction	9, 10, 11, 12, 13
		Convection	14, 15, 16, 17
		Radiation	18, 19, 20
Total			20

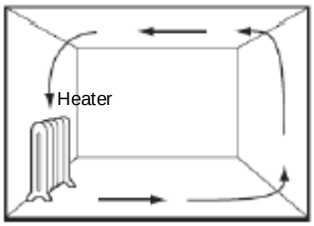
Each set of questions consists of four tiers. Questions in tier one are made in the form of multiple choices with four options. The second tier is about the confidence level of the answer on the first tier. There will be two options which are sure and not sure. The third tier will be about the scientific reason for the answer on the first tier. There will be four options in the third tier. The fourth tier is about the confidence level of the answer on the third tier. The sample question is shown in Table 3.3. So in total, 40 questions were tested and analyzed.

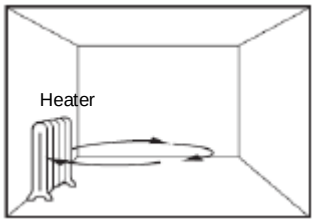
Table 3.3

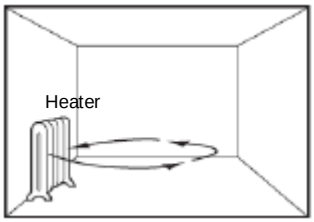
Sample Question

No.	Tier	Question
15.	1.	Which diagram shows the movement of air that can produce convection currents when a room is heated?

A. 

B. 

C. 

D. 

2. Are you sure about your answer?
   A. Sure
   B. Not Sure

3. Reason:
   A. Air close to the heater will expand so that its density is **smaller** and will move sideways and then replaced with air with a **bigger** density
   B. Air close to the heater will expand so that its density is **bigger** and will move sideways and then replaced with air with a **smaller** density

No.	Tier	Question
		C. Air close to the heater will expand so that its density is **smaller** and will move up and then be replaced with air with a **bigger** density D. Air close to the heater will expand so that its density is **bigger** and will move downward and then be replaced by air with a **smaller** density
	4.	Are you sure about your answer? A. Sure B. Not Sure
Scientific concept		If the air temperature is high, the density will be smaller so the air will move and replaced by air with a lower temperature.

In Table 3.3, the question is to see students' conception on one of the concept of convection that convection is caused by the difference in density between hotter regions of the air and cooler regions. If the air temperature is high, the density will be smaller so the air will move up and be replaced by air with a lower temperature. This concept of convection is used in how the heater works. The students then are asked to find the correct direction of convection current in the heater. Students are also asked to choose their reason and the confidence level both of the first and the third tiers.

The instrument undergoes one stage of development. The development involves 47 students. In this stage, the 29 sets of questions are administered to students via Google form. Then the result is tested for validity and reliability using SPSS. The questions that are classified as invalid questions then not used for data collection.

3.4.1 Validation Test

Once the instrument is administered to students, it undergoes a validity test. Both tier one and tier three should be valid for the question to be considered valid (Caleon & Subramaniam, 2010). The result of the correlation test is shown in Table 3.4. Correlation or validity test is done with Pearson Correlation test. It is to see the relation of two variables (Cooksey, 2020). The Pearson correlation coefficient for 47 respondents, 2 tailed test, in 0.05 significance level is r(47)= 0.288 (Pearson Education, 2017). The question is valid and can measure the variable wanted when the coefficient

is more than 0.288. From table 3.4, it can be concluded that all questions are valid except Q1, Q8, Q17, Q21, Q22, Q25, Q26, Q27 and Q29.

Table 3.4

Result of Validity Test

Question	Pearson Correlation	Interpretation	Decision	Question	Pearson Correlation	Interpretation	Decision
Q1	0.023	NOT VALID	Not used	Q16	0.364*	VALID	Used
Q2	0.382**	VALID	Used	Q17	0.087	NOT VALID	Not used
Q3	0.559**	VALID	Used	Q18	0.417**	VALID	Used
Q4	0.296*	VALID	Used	Q19	0.378**	VALID	Used
Q5	0.390**	VALID	Used	Q20	0.511**	VALID	Used
Q6	0.337*	VALID	Used	Q21	0.082	NOT VALID	Not used
Q7	0.353*	VALID	Used	Q22	0.357	NOT VALID	Not used
Q8	0.177	NOT VALID	Not used	Q23	0.482**	VALID	Used
Q9	0.417**	VALID	Used	Q24	0.534**	VALID	Used
Q10	0.382**	VALID	Used	Q25	0.272	NOT VALID	Not used
Q11	0.472**	VALID	Used	Q26	0.338	NOT VALID	Not used
Q12	0.595**	VALID	Used	Q27	0.96	NOT VALID	Not used
Q13	0.572**	VALID	Used	Q28	0.0457**	VALID	Used
Q14	0.354*	VALID	Used	Q29	0.072	NOT VALID	Not used
Q15	0.329*	VALID	Used				

In other words, from 29 set of questions that have passed the validity test, there are 20 questions that are considered valid and used as the final instrument to diagnose students' misconception on Heat Topic.

Furthermore, for the content validity, false negative and false positive probabilities were examined and expert opinions were taken into consideration. Hestenes and Halloun (1995) defined the false negative score as the correct conceptions with wrong responses while false positive score as wrong conceptions with correct responses. They recommended a false negative and false positive probability of less than 10%. In this study, the false negative and positive scores of the students in the heat misconception test were 8.51% & 11.22%. For expert opinions, the opinions of two different experts about the test were taken, and the test was revised according to these opinions. Two different expert opinions were taken regarding the accuracy of the test items in terms of scientific knowledge, the appropriateness of the misconception in terms of measurement, the comprehensibility of the language, and the suitability of the test in terms of assessment. The test was revised in accordance with the opinions of the experts and sent back to the experts. The test was given to the participants after the approval of the experts.

3.4.2 Reliability Test

The valid questions from the first test then underwent two types of reliability tests. The questions are reliable with 0.785 and 0.869 Cronbach's Alpha Score. With that score, the instrument is fairly high and considered acceptable (Taber, 2018). The Cronbach's Alpha score can be seen in Table 3.5. In total, there are 20 sets of questions that are feasible to diagnose students' conception on Heat topic.

Table 3.5

Result of Reliability Test

Category	N of Items	Cronbach's Alpha
Scientific Knowledge	20	0.785
Misconception	20	0.869

The first type of reliability score of the four-tier instrument was calculated according to the score that the students responded correctly to the first and third tiers and said confident to the second and fourth tiers, and the Cronbach's Alpha reliability score of the test was found to be 0.785. This calculation shows the reliability coefficient that is valid in case the test is used in order to reveal the scientific knowledge of students about heat. The second type of reliability score of the four-tier instrument was calculated according to the score that the students said confident to the second and fourth tiers and responded incorrectly to both first and third tiers. The Cronbach's Alpha reliability score of the test was 0.869. This calculation shows the reliability score that is valid when the test is used to reveal students' misconceptions about heat.

3.5 Research Procedure

The research is carried out in three stages as shown in Figure 3.1. Those stages are preparation stage, implementation stage, and completion stage. Furthermore, the stages are elaborated below.

1. Preparation Stage
   a. Identify the research problem and elaborate it into several research questions.
   b. Analyzing the heat topic on the 2013 National Curriculum.
   c. Analyzing the existed instruments related to diagnosing students' conception on heat topic.
   d. Constructing the instrument from the concepts of heat that have been analyzed.
   e. Administering the instrument to students who are not included in the research sample with Google Form (https://forms.gle/XwtUaMdkxHDhuw6LA).
   f. Running the validity test on the result.
   g. Revising instrument based on experts' opinion.
   h. Running the reliability test on the result.

2. Implementation Stage

   In this stage, the four-tier diagnostic test is administered to students online with Google Form (https://forms.gle/c8tS8occ6rcrZVCw6). The test consists of 20 sets of questions in total. Students filled in the question on their own without the presence

of the researcher. There is only one questionnaire that is administered to the 7th graders. The link of the questions was administered online for about three weeks from May 19th, 2022 to June 9th, 2022.

3. Completion Stage

a. Analyzing the data that has been collected statistically. To diagnose students' conception, MS-Excel program is used. Meanwhile to compare the misconceptions between male and female students, the Mann-Whitney U test is used.
b. Constructing the discussion based on data analysis and interpretation.
c. Constructing conclusion and recommendation based on the result and discussion.

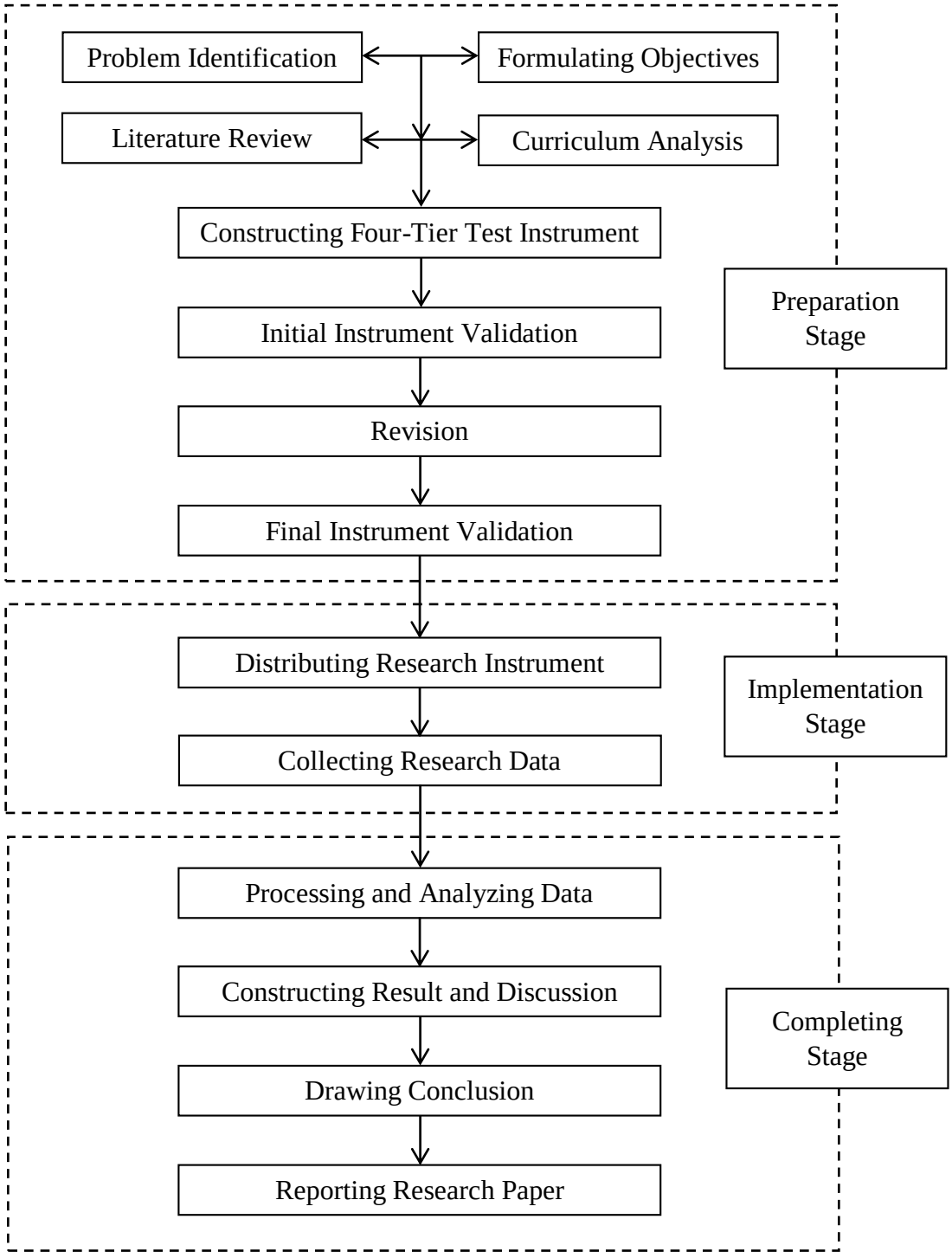


Figure 3.1 Research Procedure Flowchart

3.6 Data Analysis

The data collected were analyzed. Answers for each question will be categorized into scientific knowledge (SK), lack of knowledge (LK), misconception (M), false negative (FN), and false positive (FP) as can be seen in Table 3.6 (Kiray & Simsek, 2020). Scientific knowledge is when students answer the first-tier correctly, are sure about the first-tier, answer the third-tier correctly, and are sure about the third-tier. False positive is when students answer the first-tier correctly and are sure about the first-tier, but they answer the third-tier incorrectly and are sure about the third-tier. False negative is when students answer the first-tier incorrectly but are sure about the first-tier and they answer the third-tier correctly and are sure about the third-tier. Misconception is when students answer the first- and the third-tier incorrectly but are sure about both the first- and the third-tier. Combinations other than those mentioned before is categorized as lack of knowledge.

Table 3.6

Combination Answer and Decision of Four-Tier Test

1st Tier	2nd Tier	3rd Tier	4th Tier	Decision of Four-Tier Test
True	Sure	True	Sure	SK
True	Sure	False	Sure	FP
False	Sure	True	Sure	FN
False	Sure	False	Sure	M
True	Sure	True	Not Sure	LK
True	Not Sure	True	Sure	LK
True	Not Sure	True	Not Sure	LK
True	Sure	False	Not Sure	LK
True	Not Sure	False	Sure	LK
True	Not Sure	False	Not Sure	LK
False	Sure	True	Not Sure	LK
False	Not Sure	True	Sure	LK
False	Not Sure	True	Not Sure	LK

1st Tier	2nd Tier	3rd Tier	4th Tier	Decision of Four-Tier Test
False	Sure	False	Not Sure	LK
False	Not Sure	False	Sure	LK
False	Not Sure	False	Not Sure	LK

The analysis of the data was done with Excel program by considering the probabilities in Table 3.6. For example, when coding the scientific knowledge, students' answers to the first and third tiers of the questions in the test should be correct and their answers to the second and fourth tiers should be confident (1-1-1-1). Thus, the score of "1" was given to the sequence containing four ones. The score of "0" was given to all of the possible sequences except this sequence and then scientific knowledge scores were coded. Similarly, while false positive was coded as "1" with the correct answer at the first tier, wrong answer at the third tier, and confident at the second and fourth tiers (1-1-0-1); false negative was coded as "1" with the wrong answer at the first tier, correct answer at the third tier, and confident at the second and fourth tiers (0-1-1-1). Misconceptions was coded as "1" with the wrong answer at the first tier, confident at the second tier, wrong answer at the third tier, and confident at the fourth tiers (0-1-0-1). To analyze the lack of knowledge category, code "0" was given to the SK, FN, FP, and M sequences. Other than those sequences, the answers were categorized as lack of knowledge and were coded as "1".

In the process of data analysis, frequencies and percentages were calculated. In the first stage, the level of scientific knowledge, misconceptions, false positives, false negatives, lack of knowledge of the students about the 2 sub-topics of the 20-item test was calculated according to the criteria in Table 3.6. In the second stage, the percentage values of misconceptions were calculated and misconceptions with percentage more than 12.5% were analyzed. In the last stage, the misconceptions between male and female students' also analyzed in order to find whether there is significance difference or not.