

CHAPTER III

RESEARCH METHODOLOGY

3.1 Research Design

This research is a survey design research. Survey research describes the trend, attitude, opinion, or other characteristics by taking numbered data from the population sample without any intervention (Creswell, 2009). This is aligned with the aim of this research that is to diagnosed students' conception on light and optic topics. Since there is no intervention made, this research used a non-experimental design. The researcher will portray students' conception as what it is.

A survey crosssectional method is used for the research. The method means the researcher administered an instrument to collect data from the sample at a particular point of time (Cohen, Manion, & Morrison, 2007). The questionnaire is administered online and the sample filled it in without the presence of the researcher. The data is then collected for about 4 weeks. From the data collected researcher analyzed the data and interpret it to map students' conception on light and optic topics.

3.2 Sample

The sample that are chosen in this research have several characteristics. The characteristics are the learning process that they undergo is using the 2013 National Curriculum, they also attend junior high schools that are located in the West Java Province, Indonesia. All grades are included such as 7th graders, 8th graders, and 9th graders. Sample of convenience is used in this research. It is done by taking samples from those who are easy to reach (Wu & Thompson, 2020). This sampling method is very suitable for this research because this research needs lot of participants and has a limited time.

There are 817 students involved in this research and the distribution is shown in Table 3.1. The sample in this research come from 17 different junior high schools. These schools are located within 4 out of 27 regions of West Java Province. In this research, all students are categorized into two groups. Group 1 consists of students that have been taught light and optic topics and group 2

consists of students who have not. This grouping is done because there are some schools that do not deliver light and optic topics in the eight grade due to lack of time. Therefore grouping students by grade is irrelevant.

Table 3.1
Participant Distribution

| Category | Gender | | Number of students | Percentage(%) |
|---|--------|--------|--------------------|---------------|
| | Male | Female | | |
| Students who have learnt Light and Optic Topics | 146 | 226 | 372 | 45.5 |
| Students who have not learnt Light and Optic Topics | 181 | 264 | 445 | 54.5 |

3.3 Operational Definition

Below are the operational definitions for this research.

1. Students' Conception

Students' conception is students' beliefs, theories, meanings, and explanations that they develop throughout their experience both inside and outside schools. In this research students' conceptions were measured with a four-tier diagnostic test consists of 19 sets of questions. Students' conceptions were categorized into 5 which are scientific knowledge, false positive, false negative, misconception, and lack of knowledge. Students' conception that are diagnosed in this research is specifically on Light and optic topics.

2. Misconception

Students' misconception is when students believe a wrong conception. This is diagnosed when students answer incorrectly on the first- and third-tier but they are sure for both tiers.

3. Four-tier Diagnostic 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 categorized as scientific knowledge, false positive, false

negative, misconception, and lack of knowledge. The frequencies and percentages were analyzed statistically to map students' conception regarding light and optic topics. Furthermore, the result from both groups were compared to see if there was any significant difference between the groups.

4. Light and Optic Topics

The light and optic topics are one of the physics topics in the 2013 National Curriculum. The topic is delivered to students in the second semester of 8th grade. Four subtopics will be studied in this research. Those subtopics are the properties of light, image formation on mirrors, humans eyes, and optical instruments. The four-tier diagnostic test was made based on this topic.

3.4 Research Instrument

The instrument is needed to collect data from the participant. In this research, a four-tier diagnostic test on Light and optic topics is used to diagnose students' conception on the topics. The instrument is developed based on a list of indicators from the previous research with several changes (Widiyatmoko & Shimizu, 2018). There are 19 sets of questions constructed. There are four sub-topics which are the properties of light, the formation of images on mirrors, human eyes, and optical instruments. The distribution and the indicators can be seen in Table 3.2.

Table 3.2
Distribution of Questions

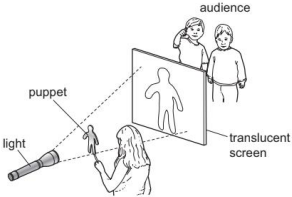



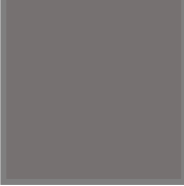
| Sub-Topic | Indicator of Question | Item |
|-----------------------------------|--|------|
| The properties of light | Light as magnetic wave | Q1 |
| | The relationship between light and vision | Q2 |
| | Monochromatic and polychromatic light | Q3 |
| | Light refraction | Q4 |
| | Light pass through materials | Q5 |
| | Light travel in a straight line | Q6 |
| | The moon reflects light | Q13 |
| The formation of image on mirrors | Distance of image in plane mirrors | Q7 |
| | Left-right reverse in plane mirror image | Q8 |
| | The angle between mirror, object, and image in plane mirrors | Q9 |
| | Formation of Image between two plane mirrors | Q10 |
| | Convex mirror image characteristics | Q11 |
| | Concave mirror image characteristics | Q12 |

| Sub-Topic | Indicator of Question | Item |
|--------------------|--------------------------------------|------|
| Human Eye | Myopia | Q14 |
| | Hypermetropia | Q15 |
| | Concave lens correcting myopia | Q16 |
| | Convex lens correcting hypermetropia | Q17 |
| Optical Instrument | What can be seen with microscopes | Q18 |
| | Type of mirror in microscopes | Q19 |

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 2 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 4 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, 38 questions were tested and analysed.

Table 3.3

Sample Question

| Tier | No | Question |
|------|----|--|
| 1 | 5a |  <p>Shadow puppets are figures that are placed between a light and a screen. Moving them creates the illusion of moving images on the screen. An experienced puppeteer can make figures appear to walk, talk, fight and dance. Shadow puppetry is a popular form of entertainment in countries all over the world. The woman uses a thin, white fabric. What would the audience see if the screen were changed into white solid wood?</p> <div style="display: flex; flex-wrap: wrap; justify-content: space-around;"> <div style="text-align: center;"> <p>A. </p> </div> <div style="text-align: center;"> <p>B. </p> </div> <div style="text-align: center;"> <p>C. </p> </div> <div style="text-align: center;"> <p>D. </p> </div> </div> |

| Tier | No | Question |
|------|----|---|
| 2 | b | Are you sure about your answer? A.Sure B. Not sure |
| 3 | c | Reason: A. All of the light rays go through the wood B. Some of the light rays go through the wood C. Some of the light rays bend and go through the wood D. All of the light rays cannot go through the wood |
| 4 | d | Are you sure about your answer? A.Sure B. Not sure |

In Table 3.3, the question is to see students' conception on one of the characteristics of light which is light pass through materials. Depends on the traits, materials are categorized into three which are transparent, translucent, and opaque. In shadow puppet, the puppeteer uses translucent materials as the screen so the spectators can see the shadow cast by the object. The students then are asked what would happen if the screen is changed into a solid white wood which is categorized as an opaque material. Students are also asked to choose their reason and the confidence level both of the first and the third tiers.

The instrument undergoes two stages of development. The first development involves 93 students. In this stage, the 19 sets of questions are administered to students via google form. Then the result is tested for validity and reliability using SPSS. The second development includes 21 students. In this stage, 6 sets of questions are retested. These questions are invalid and revised questions from the previous stage. Again, the 6 questions are administered to students via Google form. The results then undergo validity and reliability test.

3.4.1 Correlation and Reliability Test

Once the instrument is administered to students, it undergoes a correlation test and reliability test. Both tier two 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 93 respondent, 2 tailed test, in 0.05 significance level is $r(91)= 0.207$ while for 21 respondent is $r(19)= 0.433$ (Pearson Education, 2017). The question is valid and can measure the variable

wanted when the coefficient is more than 0.207 for the first test and 0.433 for the second test. From table 3.4, it can be concluded that all questions are valid except Q3, Q10, Q13, Q16, Q17, and Q18. The invalid questions from the previous test are then revised. There are improvements to the questions. some lines in the questions are changed, images are added, and some options are changed. After being re-administered to 21 students, the question items undergo correlation and reliability tests for the second time. All 12 questions are valid.

Table 3.4
The Result of Correlation Test

| Question | Tier | Test I | | | Test II | | |
|----------|------|---------------------|----------------|----------|---------------------|----------------|----------|
| | | Pearson Correlation | Interpretation | Decision | Pearson Correlation | Interpretation | Decision |
| Q1 | 1 | 0.249* | Valid | Directly | | | |
| | 3 | 0.349** | Valid | Used | | | |
| Q2 | 1 | 0.361** | Valid | Directly | | | |
| | 3 | 0.288** | Valid | Used | | | |
| Q3 | 1 | 0.319** | Valid | Retest | 0.655** | Valid | Directly |
| | 3 | 0.106 | Not Valid | | 0.630** | Valid | Used |
| Q4 | 1 | 0.274** | Valid | Directly | | | |
| | 3 | 0.257* | Valid | Used | | | |
| Q5 | 1 | 0.510** | Valid | Directly | | | |
| | 3 | 0.414** | Valid | Used | | | |
| Q6 | 1 | 0.499** | Valid | Directly | | | |
| | 3 | 0.375** | Valid | Used | | | |
| Q7 | 1 | 0.376** | Valid | Directly | | | |
| | 3 | 0.361** | Valid | Used | | | |
| Q8 | 1 | 0.360** | Valid | Directly | | | |
| | 3 | 0.401** | Valid | Used | | | |
| Q9 | 1 | 0.324** | Valid | Directly | | | |
| | 3 | 0.311** | Valid | Used | | | |
| Q10 | 1 | 0.154 | Not Valid | Retest | 0.638** | Valid | Directly |
| | 3 | 0.209* | Valid | | 0.638** | Valid | Used |
| Q11 | 1 | 0.252* | Valid | Directly | | | |
| | 3 | 0.325** | Valid | Used | | | |
| Q12 | 1 | 0.351** | Valid | Directly | | | |
| | 3 | 0.305** | Valid | Used | | | |
| Q13 | 1 | 0.243* | Valid | Retest | 0.696** | Valid | Directly |
| | 3 | 0.200 | Not Valid | | 0.623** | Valid | Used |
| Q14 | 1 | 0.240* | Valid | Directly | | | |
| | 3 | 0.304** | Valid | Used | | | |

| Question | Tier | Test I | | | Test II | | |
|----------|------|---------------------|----------------|----------|---------------------|----------------|----------|
| | | Pearson Correlation | Interpretation | Decision | Pearson Correlation | Interpretation | Decision |
| Q15 | 1 | 0.406** | Valid | Directly | | | |
| | 3 | 0.338** | Valid | Used | | | |
| Q16 | 1 | 0.341** | Valid | Retest | 0.576** | Valid | Directly |
| | 3 | 0.150 | Not Valid | | 0.498* | Valid | Used |
| Q17 | 1 | 0.088 | Not Valid | Retest | 0.642** | Valid | Directly |
| | 3 | 0.106 | Not Valid | | 0.555** | Valid | Used |
| Q18 | 1 | 0.245* | Valid | Retest | 0.589** | Valid | Directly |
| | 3 | -0.090 | Not Valid | | 0.589** | Valid | Used |
| Q19 | 1 | 0.250* | Valid | Directly | | | |
| | 3 | 0.252* | Valid | Used | | | |

The valid questions from the first test then underwent a reliability test. The 26 questions are reliable with 0.740 Cronbach's Alpha Score. With that score, the instrument is considered acceptable (Taber, *The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education*, 2018). The second reliability test was done for the revised questions. The 12 questions are also reliable with 0.829 Cronbach's Alpha value. This score is considered fairly high (Taber, *The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education*, 2018). The Cronbach's Alpha score can be seen in Table 3.5. In total, there are 19 sets of questions that are feasible to diagnose students' conception on light and optic topics.

Table 3.5
The Result of Reliability Test

| Test | N of Items | Cronbach's Alpha |
|------|------------|------------------|
| I | 26 | 0.740 |
| II | 12 | 0.829 |

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. Analysing the light and optic topics on the 2013 National Curriculum.
- c. Analysing the existed instruments related to diagnosing students' conception on light and optic topics.
- d. Constructing the instrument from the existing indicators.
- e. Administering the instrument to students who had been taught the light and optic topics with Google Form (<https://forms.gle/7vgcD4GM4gYtuN8M6>).
- f. Running the correlation and reliability test on the result.
- g. Revising the 6 invalid questions.
- h. Administering 6 invalid questions to students who had been taught the light and optic topics with Google Form (<https://forms.gle/VyCcjt7XCw1Lq2AE6>).
- i. Running the correlation and reliability test on the result.

2. Implementation Stage

In this stage, the four-tier diagnostic test is administered to students online with google form. The test consists of 19 sets of questions in total. Students filled in the question on their own without the presence of the researcher. There are three questionnaires with the same content. One for students who have learnt the topics (<https://forms.gle/crqW33cXBWHAzrtP9>), one for students who have not (<https://forms.gle/eoWpY73Qv17DQnybA>), and one for public (<https://forms.gle/nEo8LazH1fEQVAUd9>). The Questionnaire for the public has additional questions to confirm if they have learnt the topics or not. The link of the questions was administered online for about 4 weeks from May 24th 2021 to June 25th 2021.

3. Completion Stage

- a. Analysing the data that has been collected statistically. To diagnose students' conception, a certainty response index is used. Meanwhile to compare the conceptions between the group who has been taught the topic and who has not, 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.

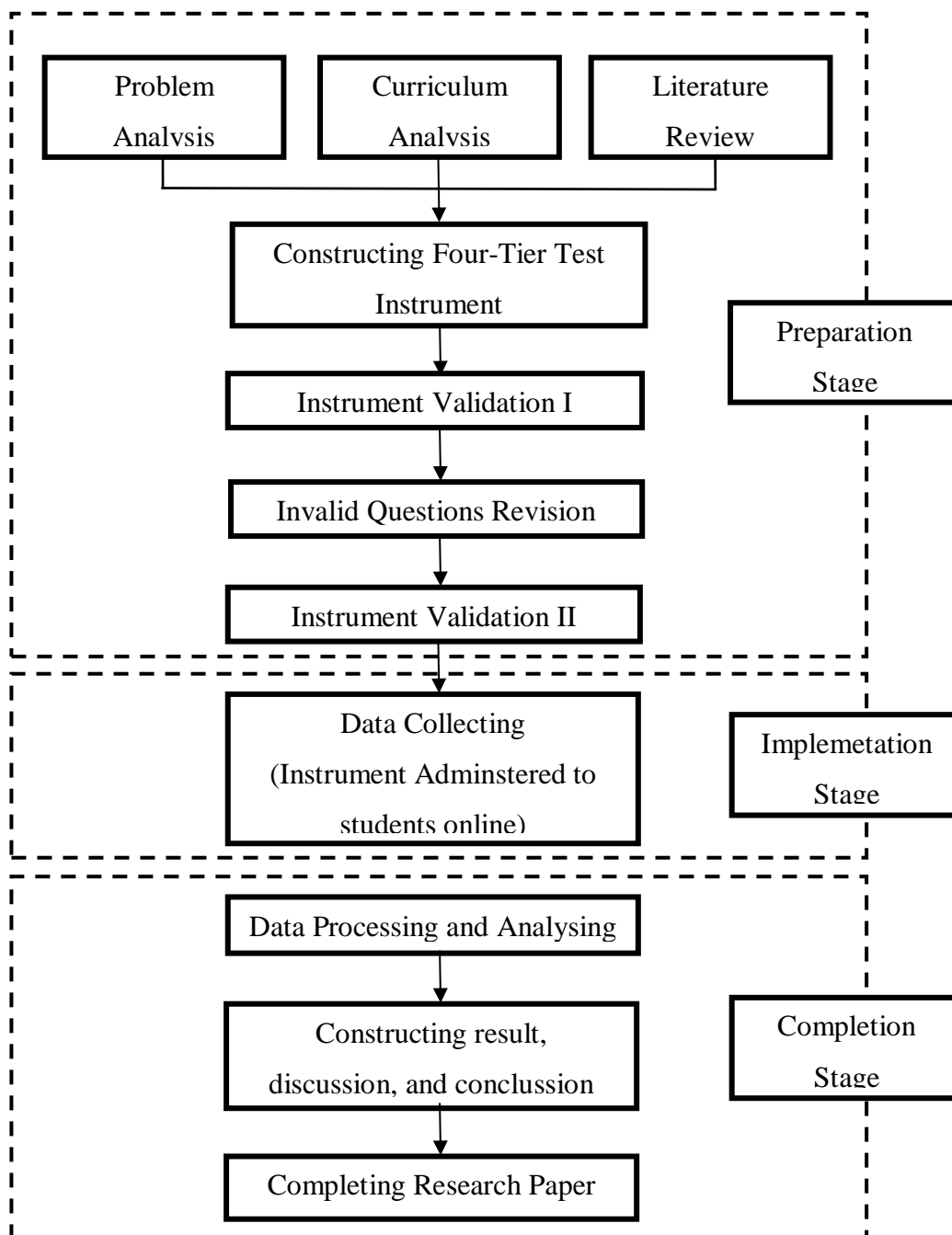


Figure 3.1 The Flowchart of Research Procedure

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 3.8 (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 3.8
Combination Answer and Decision on Four-tier Test

| Tier 1 | Tier 2 | Tier 3 | Tier 4 | 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 |
| False | Sure | False | Not Sure | LK |
| False | Not Sure | False | Sure | LK |
| False | Not Sure | False | Not Sure | LK |

The data analysis was done with Excel Program based on the combinations and decisions in Table 3.8. Correct answers for the first- and the third-tier was scored “1” while the incorrect answers were scored “0”. For the second- and the fourth-tier, option sure was scored “1” and option not sure was scored “0”. Each categories was analyzed on different sheets.

From that scores, answers that had “1-1-1-1” sequence categorized as scientific knowledge (SK) and were coded “1”. Other than that sequence, the code given were “0”. Similar coding was also applied for other categories such as false negative, false positive, and misconception. On another sheet, answers that had “1-1-0-1” sequence categorized as false positive and were coded as “1”. Other sequences were coded as “0”. On another sheet, answers that had “0-1-1-1” sequence categorized as false negative and were coded as “1”. Other sequences were coded as “0”. On another sheet, answers that had “0-1-0-1” sequence categorized as misconception and were coded as “1”. Other sequences were coded as “0”. To analyse 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”.

Frequencies and percentages were calculated in the data analysis. In the first stage, the percentages of scientific knowledge, false positive, false negative, and misconception were analyzed. The value of students’ conception was tested with the Mann-Whitney U test. This is a test to see if there is any significant difference between the two independent groups (Cooksey, 2020). On the second stage, the questions with more than 50% misconception were also analysed. The option combination of students answer on those questions were analyzed deeper. Frequencies and percentages were also calculated.