CHAPTER III
RESEARCH METHODOLOGY

3.1 Research Method

The method used in this research is developmental research method. In this method the development stages of application in this research was described, and the validity and reliability of the application was also analyzed later on. Developmental research facilitates the study of new models, tools, and procedures. The method involved several stages where each stage report and analyze data on the process of the making of the application. The stages consist of sub-studies to analyze and define the instructional problem, to specify the content, to determine instrument reliability and validity, and to make a summative evaluation (Gravemeijer, 1998).

This research method is corresponded to the objectives of the research, to develop a science virtual test on levels of organization and cell transport to assess students' science process skills, because the research focuses on the development stages of the application rather than solely gathering data.

3.2 Research Design

Based on the method of developmental research, a development model has been used to systematically arrange this research. The model used in this research is called the Prototyping Development Model. The prototyping development model is a model in which the prototype of the end product is first produced, tasted and refined on a number of occasions, according to customer feedback until a final acceptable prototype is accepted. The model flow is shown as follows in Figure 3.1

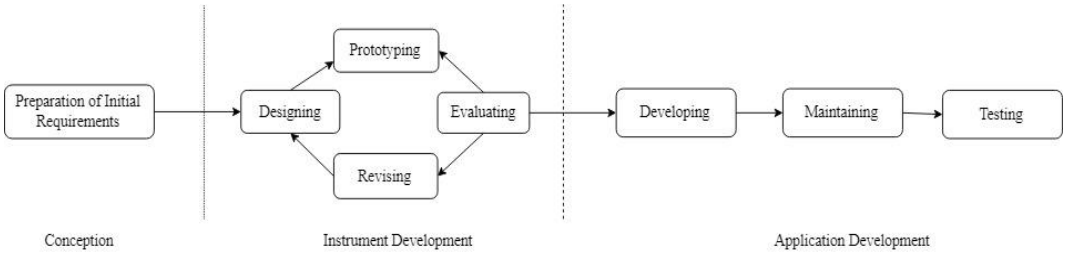

Figure 3.1 Prototyping Model Flow

The prototyping development model consists of three development stages which are conception, instrument development, and application development. The conception stage was where all the preparation needed for the instrument was analyzed, is also called the content analysis stage. The content analysis was including literature review of biological topic, science process skills, and science virtual test analysis. The instrument development stage comprises of a four-step process, namely designing, prototyping, evaluating, and revising. The application development stage was where the designed instrument constructed to become an application, where its validity and reliability was evaluated.

3.3 Research Subject

The research was conducted in two Kabupaten Bandung Private Junior High Schools, "X" and "Y." The school is a bilingual and international school that utilizes English as a language of teaching. The curriculum used in school "X" was a combined curriculum of 2013 Curriculum and Cambridge Curriculum, while in school "Y" Curriculum 2013 was used. The schools are suitable to be selected because the tool is designed to be applied to the biology class of 7th graders that utilizes the Curriculum 2013 and Cambridge curriculum.

The schools are selected as being accredited by the Ministry of Education of Indonesia as "A." In order to support the conduction of the research, the schools must have appropriate quality in technology facilities. The subjects were representative students from five classes of the two schools' 7th graders. Because it is better to get more than 100 respondents to have appropriate and reliable data.

3.4 Operational Definition

In order to make the research more focus, some variables in the research are elaborated. The operational definitions of this research are explained as follows:

1) Science Virtual Test

Virtual science test is a computer testing test. The test was developed with Adobe Flash Professional CS6 and Macromedia Flash Professional 8.0. The exam consists of four various options with the scientific process skills instrument within the test (multiple choices), validated by expert judgments, readability test by teachers and students, and students' impressions. Several media such as video,

audio, figures, graph, table, and news article have been used in this test. The validity of the science virtual test that was evaluated by rubric evaluation through experts' judgement and analyzed through IBM Statistics 24 and ANATES 4.1.0.

2) Science Process Skills

Science process skills that involved in this research is developed by Rezba, Sprague & Fiel (2003) and Rustaman (2010) that has been formulated into eight skills consisted of interpreting, communicating, classifying, predicting, raising questions, hypothesizing, planning an experiment/investigation, and applying concept. The skills are completed with indicators of each skills. The science process skills were assessed by objective test from the instrument.

3.5 Research Instrument

In validating and developing science virtual test as well as recording students' impression an appropriate instrument is necessary to be used in the research. There are two instruments in this research; rubric and questionnaire. The instruments are elaborated as follows.

3.5.1 Rubric

The validation of science virtual test was divided into media, content, and educational aspects as each element had different aspects to validate.

1) Media Experts' Rubric

There are several aspects that should be judged by experts regarding media: (1) composition of text color, text size, and text font (2) arrangement of each components in layout (neatness, easy to read, not to give confusion) (3) appropriate navigation/icon/picture usage in the test (placement, quality, size, color, appropriate function) (4) the position, and navigation bottom were consistent and it has the same color and function for each screen (5) harmony between test, font, and background on the layout (6) information in the media (video, animation, audio, background sound) have clear intonation, appropriate tempo, clear sound (7) background sound/ sound effect attracting but not distracting.

Table 3.1
Rubric for Experts' Judgement in Media

Skills of science process skills	Indicators of the skills	Assessed Aspects	Experts' Assessment (✓) Yes	No
Interpreting	Indicators	Composition of text color, text size, and text font		
Communicating		Arrangement of each components in SVT-LOCT layout (neatness, easy to read, not to give confusion)		
Classifying		Appropriate navigation/ icon/ picture usage in the SVT-LOCT (placement, quality, size, color, appropriate function)		
Predicting		The position, and navigation bottom were consistent and have the same color and function for each screen.		
Raising Questions		Harmony between text, font, and background on the layout		
Hypothesizing		Information in the media (video, animation, audio, background sound) have clear intonation, appropriate tempo, clear sound		
Planning Experiment/ Investigation				
Applying Concept		Background sound/ sound effect attracting but not distracting		

(Source: Rusyati & Firman, 2017; Rezba et al., 2003; Rustaman, 2010)

2) Content Experts' Rubric

Aspects to be judged by experts in terms of content are: (1) figure/graph/article/videos/audio/animations used are appropriate with concept and rule of organizational system of life (2) the caption/explanation/story regarding figure/ table/ graph/ picture/ animation/ articles/ story were appropriate with the concept and rule of organizational system of life (3) information regarding "organizational system of life" has been clearly presented (4) Using the correct term in accordance with the rules of Biology.

Table 3.2
Rubric for Experts' Judgement in Content

Sub-skill of science process skills	Indicators of the skill	Assessed Aspects	Experts' Assessment (✓) Yes	No
Interpreting Communicating Classifying Predicting Raising Questions Hypothesizing	Indicators	Figure/ graph/ article/ videos/ audio/ animations used are appropriate with concept and rule of levels of organization and cell transport The caption/ explanation/ story regarding figure/ table/ graph/ picture/ animation/ articles/ story were appropriate with the concept and rule of levels of organization and cell transport		
Planning Experiment/ Investigation		Information regarding "levels of organization and cell transport" has been clearly presented		
Applying Concept		Using the correct term in accordance with the rules of Biology.		

(Source: Rusyati & Firman, 2017; Rezba et al., 2003; Rustaman, 2010)

3) Education Experts' Rubric

Education aspect to be judged by experts are: (1) questions used are in accordance with sub skills of science process skills developed by Rezba et al (2003) and Rustaman (2010) as in the Table 3.3.

Table 3.3
Rubric for Experts' Judgement in Education

Sub-skill of science process skills	Assessed Aspects	Experts' Assessment (✓) Yes	No
Interpreting Communicating Classifying Predicting Raising Questions Hypothesizing Planning Experiment/ Investigation Applying concept	Questions used are in accordance with sub skills of science process skills		

(Source: Rusyati & Firman, 2017; Rezba et al., 2003; Rustaman, 2010)

4) Language Experts' Rubric

Language aspects to be judged by experts are: (1) Grammar in questions and options are in appropriate use and (2) Using the appropriate English term in the questions as seen in Table 3.4.

Table 3.4
Rubric for Experts' Judgement in Language

Sub-skill of science process skills	Assessed Aspects	Experts' Assessment (✓) Yes	No	Recommendation
Interpreting Communicating Classifying Predicting Raising Questions Hypothesizing Planning Experiment/ Investigation Applying concept	Grammar in questions and options are in appropriate use Using the appropriate English term in the questions			

(Source: Rusyati & Firman, 2017; Rezba et al., 2003; Rustaman, 2010)

5) Teacher and Students' Readability Test

Teachers and students are also asked to fill the rubric of readability of the science virtual test with the rubric above.

Table 3.5
Rubric for Teachers and Students' Readability Test

Sub-skill of science process skills	Assessed Aspects	Experts' Assessment (✓) Yes	No
Interpreting Communicating Classifying Predicting Raising Questions Hypothesizing Planning Experiment/ Investigation Applying Concept	The description of the article/ figure/ picture/ video/ table/ graph was easy to comprehend. The questions are easy to understand The option are easy to understand There is correlation between questions and answer There was no ambiguous word/term which made students find difficulties in comprehending the question.		

(Source: Rusyati & Firman, 2017; Rezba et al., 2003; Rustaman, 2010)

3.5.2 Questionnaire

The questionnaire is used to record students' impression after using the science virtual test. It consists of four aspects which are experience, technical, preference and media.

Table 3.6
Questionnaire of Students' Impression

Aspect	Statement	SA	A	D	SD
Experience	The science virtual test was fun and comfortable				
	The science virtual test is easier to operate than I thought				
	The science virtual test didn't make me feel as nervous as paper based-test				
	I could understand more about the question with science virtual test rather than with paper based-test				
	I think the science test is not confusing				
	I think using science virtual test is very effective				
Technical	I don't find any difficulties in using science virtual test				
	I could insert my identity easily on the test				
	I prefer to have my science test result automatically as in science virtual test				
	I can submit my final answer with no problem				
	I don't find it difficult to edit my answer on the test				
	I don't find any problem in using science virtual test				
Preference	I prefer taking test with science virtual test than paper-based test				
	In my opinion science virtual test is easier to do than paper test				
	I think virtual test is more effective than paper test				
	I think science virtual test is better than paper test				
Media	I think composition of text colour, text font, and text size is comfortable to read				
	I think background and overall layout of the test is good				

Aspect	Statement	SA	A	D	SD
	I think the quality of picture in term of colour, placement, and size is pretty good				
	I can understand the caption/text in the test easily				
	I think the quality of table in term of colour, placement, and size is pretty good				
	I think the quality of graph in term of colour, placement, and size is pretty good				
	I think the position, and navigation botton were conistent and it has the same color and function for each screen.				
	I can listen to the video and audio clearly without any distraction				

SA= Strongly Agree; A= Agree; D= Disagree; SD= Strongly Disagree
(Adopted from: Terzis, 2001; Feyzioğlu, 2009; Rusyati & Firman, 2017)

3.6 Instrument Analysis

3.6.1 Validity

Validity refers to the appropriateness, meaningfulness, correctness, and usefulness of the inferences a researcher makes (Fraenkel, Wallen, & Hyun, 2011). The validity test was judged by the expert to check the test instrument valid or not to measure students' science process skills on levels of organization and cell transport topic.

$$r_{xy} = \frac{n\Sigma\,xy - [(\Sigma\,x)(\Sigma\,y)]}{\sqrt{[n\Sigma\,x^2 - (\Sigma\,x)^2][n\Sigma\,y^2 - (\Sigma\,y)^2]}}$$

Where,

r_{xy} = items correlation coefficient.
X = items scores
N = amount of subject

(Minium, Rosopa, & King, 2011)

The formula above is appropriate to be used to determine the validity of test item. Item test will be checked using ANATES version 4.1.0 while the content will be validated by experts based on majority. In order to interpret the validity, researchers use references (Jacobs and Chase, 1992) as shown in Table 3.7.

Table 3.7
Validation Interpretation Value

The amount of r value	Interpretation
0.80-1.00	Very high
0.60-0.79	High
0.40-0.59	Prosperous
0.40-0.39	Low
0.00-0.19	Very low

(Source: Jacobs and Chase, 1992)

3.6.2 Reliability

Reliability refers to the stability, dependability, or consistency of test results (Kaplan & Saccuzzo, 2009). Reliability test is necessary to investigate whether an instrument reliable enough to measure the students' science process skills or not. The analysis of reliability was done statistically using SPSS version 24. The reliability value was interpreted as shown in Table 3.7. This reliability value measurement was designed by Lee Cronbach in 1951 where factors in the scale size reliability estimation are calculated using the following formula:

$$\alpha = \frac{K}{K-1}(1 - \frac{\sum_{i=1}^{k} \sigma_{Yi}^{2}}{\sigma_x^2}$$

Where,
K = the number of items in the measure
σ_x^2 = the variance (square of standard deviation) of the observed total scores
σ_x^2 = the observed variance for item

(Cronbach, 1951)

Table 3.8
Interpretation of Cronbach formula

The amount of r value	Interpretation
0.80 – 1.00	Very High
0.60 – 0.79	High
0.04 – 0.59	Prosperous
0.02 – 0.39	Low
0.00 – 0.19	Very low

(Source: Jacobs and Chase, 1992)

3.6.3 Difficulty Level

To measures achievement or ability from the test, test item difficulty is defined by the number of people who get a particular item correct (Kaplan & Saccuzzo, 2009). The analysis of difficulty index can be determined by the formula:

$$P = \frac{B}{JS}$$

Where,
P = difficulty index
B = the number of students answering right
JS = total number of students

(Kaplan and Saccuzzo, 2009)

The interpretation of the number could be read as:

Table 3.9
Interpretation of difficulty index

Value of index of difficulty (P)	Interpretation
0.00-0.30	Difficult
0.31-0.70	Moderate
0.71-1.00	Easy

(Kaplan & Saccuzzo, 2009)

3.6.4 Discriminating Power

Discriminating power defined as the ability of the test item to discriminate high achiever students and low achiever students based on their score test (Creswell, 2012). It determines the quality of test item which can differentiate the upper and lower achiever in answering test item to assess students' science process skills on levels of organization and cell transport topic. The discriminating power will be determined using the formula, as follow:

$$D = \frac{P_H - P_L}{100}$$

Where,

D = Discrimination

P_H= average score of 27% highest test score

P_L= average score of 27% lowest test score

(Kaplan and Sacuzzo. 2009)

The value of discriminating power can be interpreted using categorization that presented in the Table 3.9 below.

Table 3.10
Interpretation of Discriminating Power

Value of Discriminating Power (D)	Interpretation
0.00-0.20	Poor
0.21-0.40	Satisfactory
0.41-0.70	Good
0.71-1.00	Excellent

(Source: Kaplan and Sacuzzo, 2009)

3.6.5 Distractor Analysis

When taking multiple choice test, the author must determine which of several alternatives is correct. Incorrect choices are called as distractors. In the section on item analysis, the choice of distractors is critically important. Studies have shown that it is rare to find items for which more than three or four distractors operate efficiently. The distractor is usable if the distractor is chosen by 5% of all the respondent (Chavda, Misra, Duttaroy, & Clinic, 2015).

The formula to correct for guessing on a test is,

$$corrected\ score = R - \frac{W}{n-1}$$

Where, R = the number of right responses
W = the number of wrong responses
n = the number of choices for each item

3.6.6 Students' Attainment in Science Process Skills

Students' ability of science process skills will be categorized based on standard deviation and mean of a students' group. Mean is formulated as follows:

$$\bar{X} = \frac{\sum X}{n}$$

(Minium, Rosopa, & King, 2011)

Where, $\bar{X}$ = mean
$\sum X$ = total score
n = number of subjects

Standard deviation can be formulated as follows:

$$S_x = \sqrt{\frac{\sum(X - \overline{X})^2}{n}}$$

(Minium, Rosopa, & King, 2011)

Where, S_x = standard deviation
X = score
$\bar{X}$ = mean
n = number of students

From the formulas above, mean and standard deviation are obtained thus the categorization of students' science process skill attainment can be determined. The categorization of students' attainment is shown in Table 3.10 below.

Table 3.11
Categorization of Students' Attainment

Interval	Category
$X \geq \bar{X} + S_X$	High
$\bar{X} - S_X \leq X \leq \bar{X} + S_X$	Moderate
$X \geq \bar{X} - S_X$	Low

(Arikunto, 2013)

3.6.7 Students' Impression

Analysis of students' impression after conducting test with the instrument was done by Likert scale analysis. In using Likert scale, subject are required to read all of the statements in the questionnaire and choose the answer based on the category (Suherman, 2003). In this questionnaire the answer are categorized into four different answer with different score each, the strongly agree is 5 points, agree is 4 points, disagree 2 points, strongly disagree is 1 point, and neutral is 3 points. The average value of the answers is calculated and interpreted as shown in Table 3.11 below.

Table 3.12
Interpretation of Likert Scale

Value	Interpretation
Score > 3	Positive (+) Impression
Score < 3	Negative (-) Impression

(Suherman, 2003)

3.7 Research Procedure

There are generally three phases in the research procedures: conception stage, instrument development stage and application development stage. The research process is defined in the diagram flow (Figure 3.2).

3.7.1 Conception Stage

a. Identificating the problems
b. Formulating research objectives and benefits
c. Defining research variables
d. Analyzing literature review on science process skills
e. Analyzing literature review on science virtual test
f. Analyzing literature review of Curriculum 2013 and Cambridge IGCSE on levels of organization and cell transport topic

3.7.2 Instrument Development Stage

a. Constructing the instrument (multiple choices) of science process skills consist of 40 questions
b. Designing story board for science virtual test
c. Constructing of virtual test using Adobe Flash Professional CS6 and Macromedia Flash 8.0
d. Testing content validity to experts' in content, media, education, and language
e. Conducting teacher and students' readability test
f. Validating the instruments to the experts of media, education, content, and language
g. Revising the instrument based on test of readability and expert judgment into 30 questions of test item.

3.7.3 Implementation Stage

a. Conducting small group try to 32 students.
b. Analyzing data of small group try out by ANATES 4.1.0 and IBM SPSS ver.24
c. Revising instrument based on item analysis of small group try out.
d. Conducting larger scale test with 118 students
e. Analyzing data using ANATES 4.1.0 and IBM SPSS ver.24 to check the reliability, validity, difficulty level, discriminating power and distractors
f. Constructing result, discussion, and conclusion

g. Reporting the result

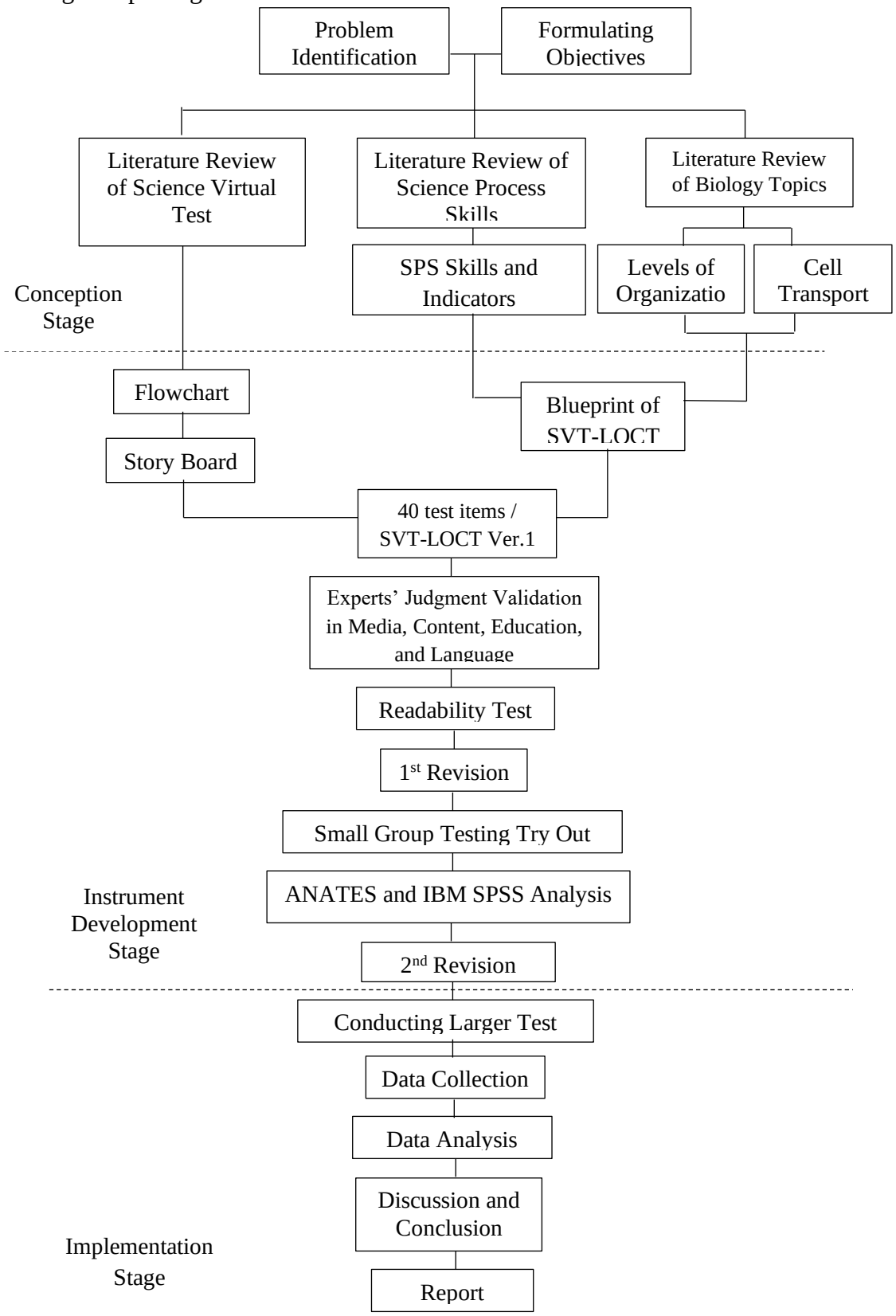

Figure 3.2 Flowchart of research procedures