CHAPTER III
RESEARCH METHODOLOGY

A. Research Method and Research Design

1. Research Method

The research method that used in this research is Quasi Experiment. Quasi experiment includes assignment, but not random assignment of participants to groups (Creswell, 2012). Creswell (2012) stated that it can be used when the researcher cannot artificially create groups for the experiment. This method is appropriate with the purpose of this research which is investigating the effect of Inquiry based Laboratory Activity towards students' understanding about lights ad optics and understanding about nature of science (NOS).

2. Research Design

Pre-test and post-test design was used in this reseach as the research design. The researcher assigned two groups of participants. One group was taken as the experimental group and the other ones as the control groups, then the researcher administered a pre-test to both groups, conducted experimental treatment activities to the experimental group only, and then administered a post-test to assess the differences between the two groups (Creswell, 2012).

The treatment given to both group are in the same learning method, which is laboratory activity but the learning model are different. The control group used conventional model of laboratory activity while the experiment group used the inquiry based laboratory activity.

Table 3.1 Pre-test and Post-test Design

Selected Control Group	Pre-test	Non-Inquiry based Laboratory Activity	Post-test
Selected Experimental Group	Pre-test	Inquiry based Laboratory Activity	Post-test

(Cressell, 2012)

B. Population and Sample

The sampling technique that used in this research was Cluster Random Sampling. Fraenkel, Wallen and Hyun (2007) stated that cluster random sampling randomly select only one cluster as a sample and then observing or interviewing all individuals within that cluster. Even if there are a large number of individuals within the cluster, it is the cluster that has been randomly selected, rather than individuals.

Then, after the random lottery has been conducted, one class consisted of 24 students was taken as experimental class, while the other class consisted of 21 students taken as control class. Both group generally consisted of almost half males and half females with the age around 14 years old.

Table 3.2 The Percentage of Students' Gender

Gender	Experiment Class		Control Class	
	Number of Students	Percentage	Number of Students	Percentage
Male	13	54,2%	12	57,1%
Female	11	45,8%	9	42.9%
Total	24	100%	21	100%

C. Assumption

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

1. Inquiry based Laboratory Activity can give more positive effect toward students' conceptual mastery (Wolf and Fraser, 2007; Sesen and Tarhan, 2013) and understanding about Nature of Science (Ozgelen; Tuzun; and Hanuscin, 2013).
2. Students' conceptual mastery is considered as one of the importance competences that have to be attained by the students like what stated by Anderson and Krathwohl (2001) in the Revision of Bloom Taxonomy, the students are said to be understand or have good conceptual knowledge when they can build connection between "new" knowledge to be gained and their prior knowledge.

3. Students' understanding about Nature of Science (NOS) can be improved using Inquiry based Laboratory Activity since this model engage students to investigate science trough scientist way of thinking.

D. Hypothesis

Hypothesis that is tested in this research are as follow.

H_0: There is no effect in students' conceptual mastery in learning lights and optics using Inquiry based Laboratory Activity.

H_1: There is effect in students' conceptual mastery in learning lights and optics using Inquiry based Laboratory Activity.

H_0: There is no effect in students' understanding about nature of science (NOS) in learning lights and optics using Inquiry based Laboratory Activity.

H_1: There is effect in students' understanding about nature of science (NOS) in learning lights and optics using Inquiry based Laboratory Activity.

E. Operational Definition

Operational definition explained in order to avoid the missunderstand about this research. The terminologies used in this research are explained as follow:

1. Learning activities is conducted by implementing Inquiry based Laboratory Activity. This learning model was expressed in the lesson plan and assesed using the observation sheet by the observers (several teachers).
2. Students' conceptual mastery in this research is the competence of students that covers the level cognitive by Anderson and Krathwohl (2001) in The Revised Bloom's Taxonomy, such as remembering (C1), understanding (C2), applying (C3), Analyzing (C4) and Evaluating (C5). This competence was measured using an objective test that consisted 25 multiple choice questions (pre-test and post-test).

3. Students' understanding about Nature of Science (NOS) in this research was measured using a questionnaire which was adopted from Liang et al. (2008) and already judged by experts.
4. Lights and Optics

   Lights and Optics is chosen as the topic that learned in this research. The topic focused to five subtopics based on Indonesia Nasional Curriculum of 2013, which are lights properties, images formed and its characteristics, human and animal vision organs, the working principle of optical devices.

F. Research Instrument

In this research, instrument is necessary in order to be used for gaining the data. There are several types of research instruments that were used in this research. Those instruments are described below.

1. Observation Sheet

In this research, the observation sheet used to investigate the conformity of the aspect of Inquiry based Laboratory Activity, lesson plan and the real learning activity conducted by the researcher. This observation sheet contained several statement and fulfilled by the observers that have the obligation to observe and analyze the whole implementation and also to judge whether the implementation was in line with the procedure or not by giving checklist if the activity stated in the lesson plan is done by the researcher and giving cross sign for the opposite.

2. Objective Test

Objective test is the instrument that used to test the students' conceptual mastery, specifically in the lights and optics topic. The same objective test was given to the student as pretest and posttest. Both control and experiment groups were given pretest and posttes. Pretest conducted before the treatments are given. The result of this test showed the basic knowledge of the students about lights and optics topic. Then, the posttest conducted after the the treatments were given.

The purpose of posttest was to measure the improvement of the students' conceptual mastery. The type of questions that given in the pretest and posttest is multiple choice, each contained 25 questions. The multiple choice questions was constructed based on Anderson and Krathwohl (2001) in the Revision of Bloom's Taxonomy in the cognitive level of remembering (C1), understanding (C2), applying (C3), analyzing (C4), and evaluating (C5). The table below is the blue print of objective test before being analyzed and revised.

Table 3.2 The Blue Print of Objective Test Item Before Revision

Sub Topics	Level of Cognitive Domain					Total	Percentage
	C1	C2	C3	C4	C5		
Light and its properties	1,2	3,4	5	6,7	8, 9	9	22,5%
Image formed by mirror and its characteristics	12,18	13,17	10, 14	11,15	16	9	22,5%
Image formed by lense and its characteristics	19,24	20, 22, 25	21,23			7	17,5%
Human vision	26, 27	28, 29	30,	31,32		7	17,5%
Optical devices	33, 34	35, 36	37, 38	39,40		8	20%
Total	10	11	8	8	3	40	100%
Percentage	25%	27,5 %	20%	20 %	7,5 %	100 %	

All the test items were judged by the experts and tested to the students that have learned about lights and optics, then after that the students' answer was analyzed using a statistical software, namely ANATES (the detail result of test item analysis is attached in appendix). The result of ANATES was being the consideration to elliminate the test items. Some of the test items were selected, revised or deleted. The new blue print of objective test item was arranged and used as the fix research instrument. From 40 test items, there are 25 test items used. The new blue print of objective test items after being analyzed and revised was shown in the Table 3.7.

3. Student Understanding of Science and Scientific Inquiry (SUSSI)

In this research, the students' understandings about Nature of Science (NOS) was measured using Student Understanding of Science and Scientific Inquiry (SUSSI). SUSSI was a questionnaire in form of Likert-type items to asses students' understandings on the nature of science (NOS) in terms of six aspects which are observations and inferences, tentativeness, scientific theories and laws, social and cultural embeddedness, creativity and imagination, and scientific methods (Liang et al., 2008). Each of the aspects consists of four statements, the maximum score can be obtained by students in each aspects is 8, while -8 for the minimum. SUSSI questionnaire allows the use of inferential statistics to determine the effect of any instructional interventions in small or large scale study. The SUSSI questionnaire is attached in appendix.

G. Instrument Development and Analysis

The objective test that was used to measure the students' conceptual mastery was tested before it was used as pretest and posttest. The instrument development started by analyzing the curriculum applied in the chosen school. Afterwards, the reseearcher formulated and arranged the objective test.In the preparation stage, the objective test was validated and tested to the class that has learned about lights and optics, which is the 9th grade studets. The analysis of instrument consisted of the discriminating power, distractor, level of difficulty, validity and realibility.

1. Discriminating Power

Discriminating power is define as ability of particular question to distinguish the higher achiever with the lower achiever students. Discriminating power index show the scale from minus one until positive ine, with the negative one represent low discriminating power index. The result of discriminating power test then interpreted using the interpretation of discriminating power by Arikunto (2013).

2. Distractors

According to Escudero, Reyna and Morales (2000), distractors are the stuff of multiple choice items, when incorrect alternatives are offered and students have to select the correct alternatives. Here a simple frequency count of the number of times a particular alternatives is selected provided information on the effectiveness of the distractor. If it is selected several times then it is working effectively, if it is never or seldom selected then it is not working effectively and it should be replaced (Escudero, Reyna and Morales; 2000).

3. Difficulty Level

Difficulty level in this research means the ability of the test in gaining the number of students who can give the right answer in the question. The ability of students in answering difficult question is not seen from the perspective of the teacher. According to Arikunto (2013), good question is the question which is not too easy or too difficult to be answered. He also stated that the question which are too easy will not stimulate the students to try harder to solve it, while too dfficult questions will make students give up and lose heart. The categories to consider the problems are easy, medium and difficult. The proportion of three categories based on the normal curve. Means that, most of the problems are in the medium category, some are included into category of easy and difficult with balance proportion. The result of difficulty level test by ANATES then interpreted using the interpretation of difficulty level by Arikunto (2013).

4. Validity

Validity refers to the extent to which an instrument measures what it is intended to measure (Ary, Jacobs and Razavieh, 1979). While, according to Golafshani (2003) validity determines whether the research truly measures that which it was intended to measure or how thruthful the research results are. Hence, by having this validity test, it can measure whether the data that resulted from the test is valid with the variable that want to be measured and interpreted.

Content validity is the most common type of validation used by researcher to ascertain id a test provides an accurate assesment of instructional objectives (Miller, 2008). It is the most important idea to consider when preparing or selecting an instrument for use (Fraenkel, 2011). Each type of validity follows specific procedures and has primary use. In this research, ANATES software was used to measure or determine the validity of the instrument. The result then interpreted using the interpretation by Minium, King and Bear (1993), it is the interpretation about the correlation coefficient between x and y variable which is devided into different categories.

5. Reliability

Reliability refers to the consistency of scores or answers from one administration of an instrument to another, and from one set of items to another (Fraenkel, 2011). Reliable means a test must rely fit on several aspects in conducting the test item. The result of difficulty level test by ANATES then interpreted using the interpretation of difficulty level by Minium, King and Bear (1993).

H. Instrument Development and Analysis Result

1. Recapitulation of Objective Test Analysis Result

Before the objective test being used, the objective test was tested to the students that have learned about lights and optics which are the students of 9^{th} grade in the same school of the sample students. Before analyzed and judged, objective test consisted of 40 questions. The validity, realibility, discriminating power and difficulty level of the instrument was analyzed. The test was given to 23 9^{th} grade students. The recapitulation of objective test analysis result is shown in the Table 3.3.

Test Item Recaptulation

Realibility Test : 0,77 (High)

Table 3.3 The Recapitulation of Objective Test Analysis Result

Question Number	Discriminating Power	Difficulty Level	Validity	Status
1	Poor	Very Easy	Invalid	Rejected
2	Poor	Easy	Very Low	Rejected
3	Poor	Easy	Invalid	Rejected
4	Poor	Very Easy	Invalid	Rejected
5	Poor	Very Difficult	Very Low	Rejected
6	Poor	Very Easy	Invalid	Rejected
7	Good	Medium	Enough	Used
8	Good	Medium	Low	Revised
9	Good	Very Easy	Enough	Used
10	Enough	Difficult	Low	Revised
11	Good	Medium	Enough	Used
12	Enough	Medium	Enough	Used
13	Poor	Very Easy	Very Low	Rejected
14	Poor	Very Easy	Very Low	Rejected
15	Poor	Very Easy	Very Low	Rejected
16	Enough	Medium	Low	Revised
17	Poor	Easy	Very Low	Rejected
18	Enough	Very Easy	Enough	Used
19	Excellent	Medium	Enough	Used
20	Poor	Medium	Very Low	Revised
21	Enough	Difficult	Enough	Used
22	Good	Medium	Enough	Used
23	Enough	Easy	Low	Revised
24	Good	Very Easy	Enough	Used
25	Enough	Medium	Low	Revised
26	Poor	Easy	Low	Revised
27	Poor	Easy	Invalid	Rejected
28	Poor	Easy	Invalid	Rejected
29	Enough	Medium	Low	Revised
30	Good	Medium	Low	Revised
31	Poor	Medium	Very Low	Rejected
32	Poor	Medium	Very Low	Rejected
33	Good	Medium	Low	Revised
34	Enough	Medium	Enough	Used
35	Poor	Difficult	Very Low	Rejected
36	Enough	Very Difficult	Low	Revised

Question Number	Discriminating Power	Difficulty Level	Validity	Status
37	Excellent	Medium	High	Used
38	Good	Medium	Low	Revised
39	Poor	Medium	Very Low	Revised
40	Enough	Very Easy	Enough	Used

The test item has been tested in terms of validity, realibility, discriminating power and difficulty level also judgend by several experts then revised so that it is adequate to be used as the research instrument to obtain the data of students' mastery. The following table is the blue print of objective test as the research instrument to determine students' conceptual mastery which is based on cognitive domain.

Table 3.4 Blue Print of Objective Test after Analyzed

Sub Topics	Level of Cognitive Domain					Total	Percentage
	C1	C2	C3	C4	C5		
Light and its properties	1	2	3	4	5	5	20%
Image formed by mirror and its characteristics	8, 10		6	7	9	5	20%
Image formed by lense and its characteristics	11	13	12, 14, 15			5	20%
Human vision	16	17	19	18, 20		5	20%
Optical devices	21	22, 23	24	25		5	20%
Total	6	5	7	5	2	25	100%
Percentage	24%	20%	28%	20%	8%	100 %	

I. Data Analysis

The data collected from the research instrument was processed and analyzed using statistical calculation. To make the statistical calculation effective, so it helped by a software named (Statistic Product and Service

Solution) software version 17.0 (SPSS 17.0) which is a statistical program that capable to process statistic data accurately.

To measure students' conceptual mastery and understanding about Nature of Science (NOS) improvement, the data of students' score will be collected from the pretest and posttest in form of objective test for students' conceptual mastery and questionnaire for understanding about Nature of Science (NOS). The calculation process of data is explained as follow:

1. Scoring of Test

In this research, the improvement of students' conceptual mastery is measured using the data of test scores. The 25 test items were used in this research. Each multiple choice correct answer was given 4 score and each incorrect answer was given 0 score.

While the understanding about Nature of Science (NOS) was measured using a questionnaire. There six aspects which were tested, when the students were very agree with a positive statement, they were obtained 2 score, while if they were very disagree, they were obtained -2. So, the scoring range was from -48 to 48. -48 as the lowest score and 48 as the highest score they possibly got.

2. Calculation of Gain Score and Normalized Score

The gain of the students' score is pretest and posttest score difference, in order to measure the improvement of students' conceptual mastery understanding about Nature of Science (NOS). It could be assumed as the effect of the treatment. After the actual gain was calculated, then the Normalized Gain (N-Gain) was also calculated. Normalized gain was supposed to determine the categories of the improvement.

According to Hake (1999), below is the formula to calculate the gain:

$$G = Sf - Si$$

Note

G = Gain score

Sf= Posttest score

Si= Pretest score

The effectiveness of the treatment by the teacher in teaching lights and optics to improve students' conceptual mastery and understanding about Nature of Science (NOS) can be seen from the result of the normalized gain. The formula of N-Gain is shown as follow:

$$< g >= \frac{Sf - Si}{Smax - Si}$$

Note

G = Gain score

Sf= Posttest score

Si= Pretest score

(Hake,1999)

Then the normalized gain is interpreted and determined based on the criteria based on Arikunto (2013).

3. Normality Test

In statistics, normality tests are used to determine if a data set is well-modeled by a normal distribution and to compute how likely it is for a random variable underlying the data set to be normally distributed (Razali, N. & Wah, Y. B., 2011). In this research, normality was analyzed to know weather the data from experimental and control group are distributed normally or not. The anaysis used as consideration in data analysis weather the analysis using parametric or non-parametric analysis test. If both data distribute normally, then the homogenity should be tested. While, if the data distribution was not normal, the data analysis can use Mann Whitney Test. Because the data gained in this research was normal, so the homogenity should be tested as well. In this resseach, the normality was calculated using SPSS.

4. Homogeneity Test

After the normality has been analyzed, the consideration to chose the appropriate method was still not enough to be decided. Another aspect to be analyzed is the homogeneity of the data. The homogeneity test relate to the

validity of the often convenient assumption that the statistical properties of any one part of an overall dataset are the same as any other part (Krus, D.J., & Blackman, H.S., 1988). Sudjana (2005) stated that the data is homogen when the sig. value is more than 0,005. If the data normally distributed and homogenous, the hypothesis tested using T-Test, meanwhile if the data normally distribution but not homogeneous, the hyposthesis will be tested using T'-Test. In this research, the data was normal and homogen, therefore the data was analyzed using T-Test.

5. Mean Difference Test

Mean Difference Test was done to determine wheater both control group and experimental group have the same mean score or not. According to Fay, M. P.; & Proschan, M. A. (2010), if the data have normal distribution and homogenous, the mean difference will be tested using T-Test (independent sample test). While, if the data is not distributed normally but homogenous, the data should be tested using T'-Test. And if the data are not normally distributed, the data should be tested using Mann Whitney Test.

J. Research Procedure

The procedure or steps of the research are including the following activities below:

1. Preparation Stage

a. Investigating the problem and difficulties occured in teaching and learning process.

b. Determining the specific topic to be investigated in this research.

c. Analyzing several aspects that strengthen the foundation of this research, which are:

1) The curriculum that used in the school, to make sure that the topic that investigated in this reseach is appropriate with the independent variable,

2) Learning model that considered as appropriate based on the literature review conducted,

3) Learning sequence based on Inquiry based Laboratory Activity as independent variable, to be adjusted with learning strategy in this research, and
4) Students understanding about light and optics.

d. As the result of the analysis of those aspects, research problem was identified and ellaborated into several research questions arranged.
e. Designing the hypothesis of experiment.
f. In order to answer the research questions, the instruments were arranged as the tools to gain the data. Arrangement of instruments including pretest-posttest (objective test), understanding about nature of science (NOS) questionnaire and observation sheet. Instructional tools that used are lesson plan and worksheet that arranged to help the implementation of this learning model.
g. Constructing students' worksheet. The students' worksheet of each laboratory activity should be in line with the five phase of Inquiry based Laboratory Activity by Joyce, Weil and Calhoun (2004). The worksheet is different with the conventional worksheet, it provide a space to students to write their own laboratory activity objectives and they can construct their own procedure. It spent about three months to construct all the worksheets and it has been checked and judged by the science leacturer and teachers.
h. Judgement of instrument conducted by the experts.
i. Revising the research instrument after getting the suggestion and advice from the experts.
j. Conducting test of the objective test instrument conducted to identify the quality of the instrument by measuring its validity, realibility and other important aspects. The trial test were given to the students that have learned about lights and optics topic.
k. Analyzing the result of expert judgement and the trial objective test.
l. Revising research instrument based on the analysis.
m. Finding the available and possible school for conducting this research.

2. Implementation Stage

a. Conducting the pretest to identify students prior knowledge about the topic which is lights and optics, and understanding about Nature of Science (NOS).

b. Giving the treatment to both classes. The experimental class using Inquiry based Laboratory Activity, while the control class using conventional laboratory activity.

c. Implementation of Inquiry based Laboratory Activity

The implementation of Inquiry based Laboratory Activity was conducted within 10 meetings, added by one meeting in the beginning to give pretest and one meeting in the end to give posttest, so the total meeting was 12 interfaces with students. This research was conducted in one of Junior High School in Bandung on March to April 2017 with the sample students from 8^{th} Grade.

In implementing this teaching model, the observation was done in order to check and make sure that the teacher's and students' activities were already in line with the steps of Inquiry based Laboratory Activity. The observation sheets were constructed by the researcher based on the steps of Inquiry based Laboratory Activity based on Joyce, Weil and Calhoun (2004).

The score of the observation then measured from the result of each observer. There were only two categories, they are "yes" or "no", if during observation the observer found that the activity was done, then they have to add a check list mark in "yes" category, then if the activity was undone, they have to add a checklist mark in "no" category. The full format of observation sheets can be accessed in the attachment. The summary of observation sheets during the implementation of Inquiry based Laboratory Activity is shown as below in the following Table 3.5.

Table 3.5 The Summary of Observation Sheets

Subtopics	Steps/Phase of Inquiry based Laboratory Activity	Observer				Score	Category
		1		2			
		T	S	T	S		
Light and its properties	Confrontation with the problem	✓	✓	✓	✓	100	All activity done
	Data gathering (Verification)	✓	✓	✓	✓		
	Data gathering (Experimentation)	✓	✓	✓	✓		
	Organizing, formulating an ezplanation	✓	✓	✓	✓		
	Analysis of the inquiry process	✓	✓	✓	✓		
Image formed by mirror and its characteristics	Confrontation with the problem	✓	✓	✓	✓	100	All activity done
	Data gathering (Verification)	✓	✓	✓	✓		
	Data gathering (Experimentation)	✓	✓	✓	✓		
	Organizing, formulating an ezplanation	✓	✓	✓	✓		
	Analysis of the inquiry process	✓	✓	✓	✓		
Image formed by lense and its characteristics	Confrontation with the problem	✓	✓	✓	✓	100	All activity done
	Data gathering (Verification)	✓	✓	✓	✓		
	Data gathering (Experimentation)	✓	✓	✓	✓		
	Organizing, formulating an ezplanation	✓	✓	✓	✓		
	Analysis of the inquiry process	✓	✓	✓	✓		
Human vision	Confrontation with the problem	✓	✓	✓	✓	100	All activity done
	Data gathering (Verification)	✓	✓	✓	✓		
	Data gathering (Experimentation)	✓	✓	✓	✓		
	Organizing, formulating an ezplanation	✓	✓	✓	✓		
	Analysis of the inquiry process	✓	✓	✓	✓		
Optical devices	Confrontation with the problem	✓	✓	✓	✓	100	All activity done
	Data gathering (Verification)	✓	✓	✓	✓		
	Data gathering (Experimentation)	✓	✓	✓	✓		
	Organizing, formulating an ezplanation	✓	✓	✓	✓		

Subtopics	Steps/Phase of Inquiry based Laboratory Activity	Observer				Score	Category
		1		2			
		T	S	T	S		
	Analysis of the inquiry process	✓	✓	✓	✓		

Based on the observation result that taken by two observers, the implementation was done in line with Inquiry based Laboratory Activity, in all meetings the activities were completely conducted. Below is the detail explaination about the implementation of inquiry based laboratory activity.

1) Confrontation with the problem

   In this phase, the researcher which acted as the teacher explain the procedures of inquiry to the students it the experiment class. It is related to what are their role and how they should learn. After they understood about the inquiry procedures, then the researcher posed the problem related to the subtopic of lights and optics. From this problem, the students are guided to formulate a question to be investigated. Below are the problems confronted to the students in each subtopic:

   a) Lights properties: What do you feel and see if you were in a room without any lamps? Can you see something?
   b) Lights reflections: Does reflection only occur in mirror? How about the wall or the bed, can it relect the light?
   c) Image formations in mirror: What happend when you are stand up in front of a mirror? Do you see yourself in the same size and same directions?
   d) Image formations in lense: Have you ever see the rearview mirror?
   e) Human vision: Why the people who suffer myopia have to use the concave lense (-)?

2) Data Gathering (Verification)

   After the question formulated, the students are asked to obtained information regarding their questions. The researcher allowed the students to search the information from any source such as internet, book, and etc. The summary of the information should be written on the students'

worksheet. The worksheet used in this research was available in the attachment.

3) Data gathering (Experimentation)

The students are guided by the teacher to prove or to find the answer of their question through doing experiment or laboratory activity. The students are engaged to prepare and plan their own experiment.

4) Organizing, formulating an ezplanation

When the experiment has been conducted, the students are asked to observe the result and then guided by the researcher to construct the conclusion of the experiment and try to formulate the answer of their question.

5) Analysis of the inquiry process

The researcher evaluated the learning process by giving sevaral related question in order to check their understanding. And the researcher also gave clarification regarding the learning activity.

d. Conducting the posttest to measure the effect of Inquiry based Laboratory Activity.

e. Making a recapitulation from data gained to be analyzed and processed in the next stage.

3. Completion Stage

a. Analyzing the data obtained in accordance with the instrument used for each variable that measured and interpreting the data gained.

b. Arranging the discussion regarding the result of data analysis.

c. Constructing the conclusion based on the result.

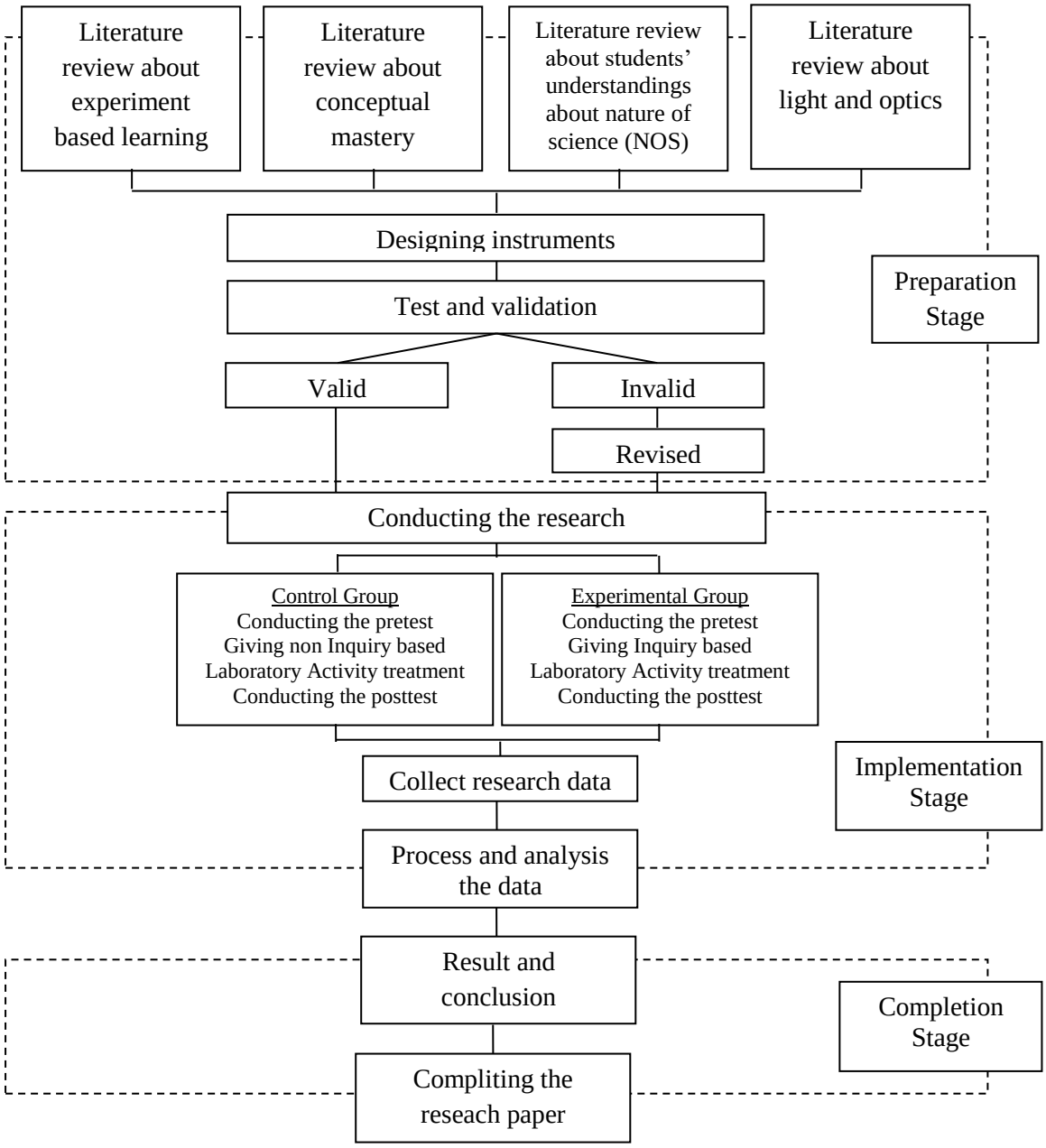

Figure 3.1 The Flowchart of Research Procedure