CHAPTER III
RESEARCH METHODOLOGY

A. Research Method and Research Design
1. Research Method

Pre-experimental was developed in this research. There is only one class as the experimental group without any control group since it is not quite appropriate to compare Nature of Science based lesson class with any traditional method of teaching. All the data was assessed through statistical means.

2. Research Design

The design that was used in this research is one class pre-test post-test design. A basic rationale for this design is that one class experienced pre-test followed by a treatment and a post-test in the end of the learning (Creswell, 2012). The pre-test was used to gain the preliminary concept mastery of students' and the post-test was used to gain the final concept mastery of students' after experienced NOS based lesson.

B. Population and Sample

This research took place in international junior high school in Bandung. This school is using National Curriculum of 2013. Data was obtained in the period of March until April 2017.

The population in this research were concept mastery of all 7th grade students at that school. The samples were concept mastery of 7th grade students from one class that consist of 22 students. The sample was obtained by using purposive sample technique since the researcher has the specific objective.

C. Operational Definition

In order to avoid misconception about this research, some operational definitions are explained in this research. There are three variables in this research which are Nature of Science based lesson as the independent variable, concept

mastery and scientific argumentation skill as dependent variable. Those variables are explained as follow:

1. Nature of Science based lesson is defined as an approach in learning science that includes aspect of nature of science during the learning process. Learning which is intended in this research is learning of science as a process for forming a knowledge that must go through a certain way through observation, thinking, experimenting or validation of the results. The learning process included 4 aspect of NOS which as empirical nature of science, tentative nature of science, science is based on social and cultural embedded and science is based on creativity and imagination.

2. Concept mastery is defined as cognitive aspect based on Bloom taxonomy. The cognitive that is measured in this research involves cognitive level of remembering (C1), understanding (C2), applying (C3), and analyzing (C4). These competences are measured by using multiple choice test with 4 options (pre-test and post-test) as the objective test.

3. Students' scientific argumentation skill is defined as an assertion or a claim and its accompanying justification. In this study, students' scientific argumentation skill is assessed by rubric developed by Erduran, to define the argumentation level.

D. Assumption

The assumptions as the foundation of this study as follow:

1. Nature of science needs to be explicitly taught to learners by deliberately focusing on various aspects of nature of science during classroom instruction, discussions, and questioning (Khishfe, 2012)

2. Inclusion of nature of science in school science curricula identified the importance of nature of science in helping people participate in argumentation and decision-making regarding socio scientific issues (Khishfe, 2013)

E. Hypothesis

Hypothesis that is tested in this study are as follow:

H_0: There is no significant improvement of students' concept mastery in learning water pollution using Nature of Science based lesson.

H_1: There is significant improvement of students' concept mastery in learning water pollution using Nature of Science based lesson.

F. Research Instrument

In this research, instrument was used for obtaining data. There are three types of instruments that were used in this research, which are objective test, questionnaire and rubric of argumentation level. Those instruments are described as follow.

1. Objective test

Objective test is an instrument which was used to assess students' concept mastery. In this study, the objective test is in form of multiple choice test. The test was given twice, before the treatment (pre-test) and after the treatment (post-test). The data was collected to measure students' concept mastery before and after treated by using nature of science based lesson in learning water pollution. The objective test consists of 20 questions with the cognitive domain of remembering (C1), understanding (C2), applying (C3), and analyzing (C4). The specification of the objective test is showed in Table 3.1.

Table 3.1 Objective Test (Pre-Post Test) Specification

Concept	Cognitive domain				Total	Percentage %
	C1	C2	C3	C4		
The cause of water pollution	3	4	-	-	7	35
The effect of water pollution	-	1	1	2	4	20
The solution for water pollution problem: filtration	2	1	1	-	4	20
The solution for water pollution problem	1	4	-	-	5	25
Percentage %	30	50	10	10	20	100

2. Rubric of Observation sheet

Observational sheet was used to measure students' scientific argumentation skill. The rubric of observation sheet was adapted from Erduran. The criteria that measured in this research were the aspects of argument raised by Toulmin which are claim, data, warrant, backing and rebuttals. The rubric of observational sheet which was developed by Erduran is shown in Table 3.2.

Table 3.2 Rubric of Argumentation Quality based on Erduran (2003)

Level	Description
5	Arguments consists of claim or counter claim which is supported by the data, warrant or support (backing) with more than one of a clear and precise rebuttal
4	Arguments consists of claim or counter claim which is supported by the data, warrant or support (backing) with rebuttal that can be identified clearly and precisely
3	Arguments consists of claim or counter claim which is supported by the data, warrant or support (backing) and contain weak rebuttal
2	Arguments consist of claim or counter claim which is supported by the data, warrant or support (backing) but does not contain the rebuttal
1	Argument consists of one simple claim or the opposite (counter claim)

3. Questionnaire of students' impression

Questionnaire was used to know the impression of the students towards nature of science based learning. The data was measured by using Likert scale. It was considered as secondary instrument, and it was processed by a percentage calculation. The blueprint of students' impression questionnaire is shown in Table 3.3.

Table 3.3 Questionnaire of Students' Impression Specification

Indicator	Category	
	Positive statement	Negative statement
Student's interest	4	4
Student's pleasure	3	3
Student's comfort	3	3

G. Instrument Development and Analysis

Research instrument development was initiated with the content analysis of 2013 curriculum that is used in school. The researcher then formulated questions to be used as an instrument of pre-test and post-test. The test used in this research was objective test consist of 20 multiple choice questions with four options.

During the development of concept mastery instrument, it has already consulted to the lecturer and some experts in related field in order to find the weakness or to gives suggestion regarding the test items that were not appropriate with the content or the readable statement of the questions.

After being revised, the instrument was tested to the group of students who already learned about the topic water pollution. Thus, the analysis of the instrument includes: validity, reliability, difficulty level, and discriminating power.

1. Instrument Test Requirement

a. Validity

Validity is the most important characteristic of any test. Kaplan and Saccuzzo (2012) describe that validity as the conformity between a test score and the quality to be measured. The quality of the test is doubtful without supportive evidence of validity (Fraenkel, Wallen and Hyun, 2007). It is defined as the extent to which the instrument measures what is designed to be measured that emphasizes not on the test itself, but on the result (Arikunto, 2010). The validity interpretation is represented in Table 3.4.

Table 3.4 Validity Interpretation

Correlation coefficient	Validity criteria
$0.80 < r \leq 1.00$	Very high
$0.60 < r \leq 0.80$	High
$0.40 < r \leq 0.60$	Satisfactory
$0.20 < r \leq 0.40$	Low
$0.00 < r \leq 0.20$	Very low

(King, Rosopa and Minium, 1993)

b. Reliability

Reliability is defined as the test item that is relatively free of measurement error. In other word, it is defined as the extent to which an instrument produces the same results on repeated trials. Although measurement error is common specifically in science but it is categorized as unreliable test item if it contains relatively high measurement error (Kaplan and Saccuzzo, 2012). Reliability interpretation is represented below in Table 3.5.

Table 3.5 Reliability Interpretation

Correlation coefficient	Validity criteria
$0.80 < r \leq 1.00$	Very high
$0.60 < r \leq 0.80$	High
$0.40 < r \leq 0.60$	Satisfactory
$0.20 < r \leq 0.40$	Low
$0.00 < r \leq 0.20$	Very low

(King, Rosopa&Minium, 1993)

c. Difficulty Level

To make a good quality of question, it has to be arranged in balanced. The proportion should consist of easy, medium and hard question. In measuring achievement, ability or skill, difficulty level is described as number of person who correctly answers particular test items. The test item is called to have optimal difficulty level if around half of respondents answer the test item correctly (Kaplan and Saccuzzo, 2012).

d. Discriminating Power

According to Cresswell (2012) discriminating power is defined as the ability of test item to discriminate students who have high and low score on a test. It is an ability of particular question to differentiate students as higher achievement and lower achievement. Good test item should be able to discriminate between high achiever students and low achiever students. Discriminating power interpretation is represented below in Table 3.6.

Table 3.6 Discriminating Power Interpretation

Category	Quality	Recommendations
0.71 – 1.00	Excellent	Retain
0.41 – 0.70	Good	Possibilities for improvement
0.21 – 0.40	Mediocre	Need to check/review
0.00 – 0.20	Poor	Discard or review in depth
< - 0.01	Worst	Definitely discard

(Arikunto, 2010)

e. Recapitulation of Students' Concept Mastery Instrument

The recapitulation of objective test as well as specification for each question item is represented on Table 3.7.

Reliability test   : 0.67 (High)

Table 3.7 Recapitulation of Test Item for Measuring Students' Concept Mastery

No	Instrument test result						Decision	New No.
	DL	Category	DP	Category	V	Category		
1	0.63	Medium	0.40	Mediocre	0.15	Very low	Revised	1
2	0.73	Easy	0.40	Mediocre	0.38	Low	Revised	2
3	0.10	Very difficult	-0.20	Worst	0.32	Low	Rejected	-
4	0.57	Medium	0.60	Good	0.58	Satisfactory	Accepted	3
5	0.73	Easy	0.80	Excellent	0.57	Satisfactory	Accepted	4
6	0.47	Medium	0.40	Mediocre	0.45	Satisfactory	Accepted	5
7	0.21	Difficult	0.60	Good	0.49	Satisfactory	Accepted	6
8	0.68	Medium	0.20	Poor	0.16	Very low	Revised	7
9	0.42	Medium	0.40	Mediocre	0.27	Low	Revised	8
10	0.78	Easy	0.40	Mediocre	0.42	Satisfactory	Accepted	9
11	0.52	Medium	0.80	Excellent	0.56	Satisfactory	Accepted	10
12	0.26	Difficult	0.60	Good	0.38	Low	Revised	11
13	0.15	Difficult	0.60	Good	0.67	High	Accepted	12
14	0.10	Very difficult	-0.40	Worst	0.32	Low	Rejected	-
15	0.21	Difficult	0.40	Mediocre	0.46	Satisfactory	Accepted	13
16	0.15	Difficult	0.00	Worst	0.27	Low	Rejected	-
17	0.31	Medium	0.20	Poor	0.17	Very low	Rejected	-
18	0.36	Medium	0.00	Worst	0.27	Low	Rejected	-
19	0.36	Medium	0.60	Good	0.52	Satisfactory	Accepted	14

No	Instrument test result						Decision	New No.
	DL	Category	DP	Category	V	Category		
20	0.10	Very difficult	0.00	Worst	0.15	Very low	Rejected	-
21	0.10	Very difficult	0.20	Poor	0.31	Low	Rejected	-
22	0.36	Medium	0.40	Mediocre	0.30	Low	Revised	15
23	0.47	Medium	0.60	Good	0.45	Satisfactory	Accepted	16
24	0.52	Medium	1.00	Excellent	0.68	High	Accepted	17
25	0.52	Medium	0.40	Mediocre	0.49	Satisfactory	Accepted	18
26	0.21	Difficult	-0.20	Worst	0.18	Very low	Rejected	-
27	0.21	Difficult	0.00	Worst	0.15	Very low	Rejected	-
28	0.47	Medium	0.80	Excellent	0.65	High	Accepted	19
29	0.47	Medium	0.20	Poor	0.14	Very low	Rejected	-
30	0.26	Difficult	0.20	Poor	0.30	Low	Revised	20

Objective test for measuring students' concept mastery in form of 30 questions has to be tested in terms of validity, reliability, discriminating power and difficulty level that are given to 19 students from grades 8 who already gained the material of water pollution before.

2. Instrument Non-Test Requirement

a. Rubrics

Argumentation level rubric was designed based on Erduran (2003). According to Erduran (2003) there are six elements which is raised by Toulmin such as claim, data, backing, warrant, qualifier, and rebuttal that aims to analyze significance of scientific argumentation skill.

The guidance to determine the component of argumentation was based on Toulmin Argumentation Pattern (TAP) which consists of claim, data, warrant, backing, qualifier and rebuttal. This instrument can assess the component of argumentation or students' opinion orally in the discussion session. Table 3.8 shows the rubric of argumentation component determination.

Table 3.8 Rubric of Argumentation Component Determination

Argumentation Component	Description	Linguistic Feature
Claim	Claim is statement of agreement. It is a statement of student based on valid source or opinion of other students.	I agree with… I support… I think ... It is right…
Counter claim	Counter claim is statement of disagree. It is a statement of student base on valid source or opinion of other students.	I disagree with … I don't concur with … It think … it is not right …
Warrant	Warrant is justification of claims made by students	Why I support … because … The things that makes me disagree is …
Backing	Data or facts is a support for warrant	Based on what I've experienced ... According to what's in the book ... When we see facts about ... From the theory, I read ... I've heard about ... The following phenomenon / data / facts prove ...
Rebuttal	Rebuttal is refinements especially against other student statements or refutations of all other group statements	I do not agree with your opinion because ... I disagree with all your statements Because .... I do not agree with you Because based on what I've experienced ...
Qualifier	Qualifier is power of data to warrants and can limit universal claims	Mostly ... Usually… Always… Sometimes…

(Roshayanti & Rustaman, 2013)

For the opinions of students which do not include the linguistic feature on the rubric, then the consideration is applied based on description of argumentation component and argumentation patterns expressed by the students.

b. Questionnaire

Questionnaire consists of twenty statements which were used to determine students' impression on implementation of Nature of Science based lesson. This questionnaire has ten positive statements and ten negative statements. These statements were used to see the consistency of student's answer. The indicator of questionnaire emphasized on students' interest, students' comfort and students' pleasure.

H. Data Processing

The different method of calculation is applied to process the qualitative and quantitative data that have been obtained during the research. Qualitative data emphasizes on students' impression after learning by using Nature of Science based lesson and the level of argumentation an skill, whereas quantitative data obtained from pretest and posttest that emphasizes on improvement of concept mastery after nature of science based lesson is applied. Calculating data procession is described as follow.

1. Data Processing of Students' Concept Mastery

Each test item in objective test is assessed based on scoring. For each correct answer is given score 5 whereas wrong and blank answer is given score 0. Scores then will be converted into 0-100 scale value. The score conversion in form percentage (%) represent based on this equation:

$$student's\ score(\%) = \frac{total\ right\ answer}{maximum\ score} \times 100\%$$

Table 3.9 Category Scale of Students' Score

Score	Category
S $\leq$ 40	Very poor
41 $\leq$ S $\leq$ 55	Poor
56 $\leq$ S $\leq$ 65	Satisfactory
66 $\leq$ S $\leq$ 80	Good

81 ≤ S ≤ 100	Excellent

Gain score (actual gain) was obtained from the difference of score of pre-test and post-test. it is used for assuming the categories of concept mastery improvement. The difference of pre-test and post-test score is assumed as the effect of the implementation the method applied in the learning process. The formula to calculate the gain score as follow:

$$G = S_f - S_i$$

Where:
G = Gain
S_f = Post-test score
S_i = Pre-test score

The improvement of concept mastery in learning water pollution after implementing nature of science based lesson is seen from the result of the normalized gain that achieved by students. For the calculations of the normalized gain value and its classification use equations as follows:

$$< g > = \frac{\%G}{\%Gmax} = \frac{\left(\%S_f - \%S_i\right)}{\left(100 - S_f\right)}$$

Where:
<g>   = Normalized gain
G   = Actual gain
G max = Maximum gain possible
Sf   = Post-test score
Si   = Pre-test score

The value of <g> is determined based on criteria on the Table 3.10.

Table 3.10 Criteria of N Gain

N-Gain <g>	Improvement Criteria
0.00 – 0.29	Low
0.30 – 0.69	Medium
0.70 – 1.00	High

(Hake, 1999)

2. Data Analysis and Hypothesis Test

a. Normality Test

Normality test was used to determine the distribution of the data. In this research, SPSS was used as supporting software to conduct normality test for pre-test and post-test. The number of the data was under 30 so that it used Saphiro-Wilk test with significant level (α) is 0.05. the result showed that the significant value was higher than 0.05. it means that the alternative hypothesis is accepted that proved the data has normal distribution.

b. Paired sample T-test

Paired T-test was done to determine the improvement of the class after the implementation of Nature of Science based Lesson that represented by comparison between pre-tests and post-test score. Since there was only one class, the comparison of post-test and pre-test is used to prove the hypothesis.

3. Data Processing of Students' Scientific Argumentation Skill

The argumentation component is collected by the transcript of argumentation from discussion session about water pollution. Identification of argumentation or the opinion of students is based on linguistic feature or main sentence that is told by students. If in the process of analyze of argumentation component determination is found the sentences that is not identified based on linguistic feature, so the sentence is considered by see the description or characteristic each component of argumentation and also the argumentation pattern based on Toulmin Argumentation Pattern.

Each identification result is written on the component argumentation determination sheet. After that the calculation of percentage for each component of argumentation is done, so that the final result gained is the number of each component of argumentation for water pollution discussion.

Students' argumentations during water pollution discussion are analyzed in the form of transcripts. Transcripts are obtained from the audio-video recording

during learning using the nature of science based lesson. The transcripts were analyzed using analyzing format of argumentation quality based on the analytical framework developed by Erduran et al. (2004). Level argumentation determination is done after the determination of the component argumentation because the presence or absence of argumentation components to be a determinant of the quality of argumentation. The description of each level is shown in the Table 3.11.

Table 3.11 Description of Argumentation Level for Data Processing

Argumentation Level	Description
Level 1	Students are only able to make choices regarding something without having a reason for the election. In other words, students are only able to say disagree or agree to something.
Level 2	Students are only able to make an argument in which it consists of a claim accompanied by a data component, warrant, backing, or qualifier. At this level argumentation does not contain a rebuttal.
Level 3	Students already able to make an argument contains weak rebuttal which its argument structure cannot be clearly identified.
Level 4	Students already able to make an argument that contains one appropriate and clearly identifiable rebuttal.
Level 5	Students already able to make arguments with more than one rebuttal.

Argumentation in the level three up to five already contains a rebuttal. Thus, the high quality of student argumentation is determined by the presence or absence of rebuttal in argumentation. After each student argument on the transcript is determined its quality, then the sum is done for each argument based on the level of argumentation.

4. **Data Processing of Students' Impression toward Nature of Science based Lesson**

Qualitative analysis of students' impression is carried out in order to analyze students' interest, comfort and pleasure towards implementation of Nature of Science based Lesson. Processing is executed by calculating Likert scale into

score then percentage conversion. The formula of converting score into percentage is seen below followed by scoring guideline of Likert scale that is represented on Table 3.12.

$$Score = \frac{Rawscore}{Maximumscore} \times 100\%$$

Table 3.12 Scoring Guideline of Students' Response

Type of statement	Scale			
	Strongly disagree	Disagree	Agree	Strongly agree
Positive statement	1	2	3	4
Negative statement	4	3	2	1

(Sugiyono, 2008)

The interpretation of score percentage is categorized into certain criteria. Table 3.13 shows the categorize of students' impression based on score percentage.

Table 3.13 Percentage Interpretation of Questionnaire

Percentage (%)	Criteria
0%	None
1%-25%	A few of criteria
26%-40%	Almost half of
41%-50%	Half of
51%-75%	Mostly
76%-99%	Generally
100%	All of them

(Arikunto, 2010)

I. Research Procedure

In order to make the research well organize, the arrangement of research procedure is planed based on the stage of Nature of Science based Lesson implementation. There are three stages of procedure consists of preparation stage, implementation stage and completion stage. Those three stages are explained as follow.

1. **Preparation Stage**

In this stage, the researcher conducts several steps that support the research, there are:

a. Preliminary study and identifying problem

b. Analyzing science content standard of junior high school

c. Literature study of Nature of Science based lesson

d. Literature study of Nature of Science aspects

e. Literature study of scientific argumentation skill

f. Constructing research proposal include designing instrument to assess variables

g. Validating instrument and expert judgment of objective test, observation sheet and questionnaire

2. **Implementation Stage**

This stage explains the step of research implementation, which are:

a. Determination of experimental class

b. Give pretest to the sample class to recognize the initial condition of students

c. Conduct research activity by implementing Nature of Science based Lesson in experimental class with following scenario:

In the first session, the aspect of nature of science that implemented in the learning process are science is empiric, science is tentative and science is based on social and cultural embedded. In this session teacher guides students to conduct discussion regarding water pollution. Each group has to discuss the cause of water pollution in the different point of view such as farmer, society, government, oil mining company and Textile Company. Each group has to raise the opinion and arguing about the others' group responsibility in polluting the water.

In the second session, the students learn through experiment. The aspects of nature of science based lesson that include in the learning process are science is empiric and science is based on social and cultural embedded. In this session, the

students have to conduct two kinds of experiment regarding the effect of water pollution to the organism. The experiment done is based on the social problem that exists around them. The first experiment is about the effect of detergent to the fish while the second experiment is about the effect of illegal logging to the ground water supply.

In the third session, the learning process is based on science is tentative, science is based on creativity and imagination, and science is empiric aspects. The topic explained in this session is the solution of water pollution problem: filtration. Each group should design the filtration system to purify the water based on their own design. At the end of the learning, each group can compare the result of each water purifier design. At the end of the session, each student has to write down the opinion regarding some activities that help to decrease water pollution.

In the fourth session, each group has to make the poster about water pollution solution. This learning is based on aspect science is based on creativity and imagination. The poster is scored based on peer assessment and the rubric that is prepared by teacher. In the end of the class, the students have to fill the post test to recognize the improvement of students' concept mastery and questionnaire to know the students' impression after learning by using Nature of Science based Lesson.

In implementing this learning, the observation was done in order to check whether the activities of teacher were already in line with the lesson plan that was made before. the observation sheets were constructed by the researcher based on the four aspects of Nature of Science based lesson. The score of observation is gained from the result of each observer. There were only two check mark for determining the learning process, for "yes" and "no". the full format of observation sheet is attached in the appendix. The result of observation during implementing Nature of Science based lesson is shown in the Table 3.14.

Table 3.14 Summary of Observation Sheet

Subtopic	Activity	Observer				Score	Category
		1		2			
		Yes	No	Yes	No		
Cause of	Introduction		✓	✓		93.75	almost

Subtopic	Activity	Observer 1 Yes	Observer 1 No	Observer 2 Yes	Observer 2 No	Score	Category
water pollution	Science is based on social and cultural embedded (spread worksheet consist article which describe the current condition of the city as an impact of water pollution)	✓		✓			all activity done
	Science is empiric inclusion (conduct discussion session regarding the cause of water pollution)	✓		✓			
	Science is tentative inclusion (guide students to construct new belief or knowledge as the result of combination of their prior knowledge and the other argumentation statement)	✓		✓			
	Closure (guide students to build a conclusion)		✓		✓		
The effect of water pollution	Introduction	✓		✓			Almost all activity done
	Science is based on social and cultural embedded inclusion (relates the topic to explain how environment is damaged as the result of water pollution)	✓		✓		90.90	
	Science is empiric inclusion (conduct experiment regarding the effect of detergent waste and deforestation to the aquatic organism and environment)	✓		✓			
	Closure (guide students to build a conclusion)		✓		✓		
the	Introduction		✓		✓	90.00	Almost

Subtopic	Activity	Observer 1 Yes	Observer 1 No	Observer 2 Yes	Observer 2 No	Score	Category
solution for water pollution problem: Filtration	Science is based on creativity and imagination inclusion (design best simple water purifier based on student's prior knowledge and creativity)	✓		✓			all activity done
	Science is empiric inclusion (observe the result of water purifier)	✓		✓			
	Science is tentative inclusion (compare each simple water purifier made to find the best design)	✓		✓			
	Closure (guide students to build a conclusion)	✓		✓			
The solution for water pollution problem	Introduction	✓		✓			
	Science is based on creativity and imagination inclusion (make poster about solution to decrease water pollution problem)	✓		✓		100	all activity done
	Closure (decide the best poster and make a conclusion)	✓		✓			

3. Completion Stage

a. Analyze result of objective test, questionnaire and rubric

b. Discuss and conclude data of analysis result

c. Research report arrangement

J. Research Plot
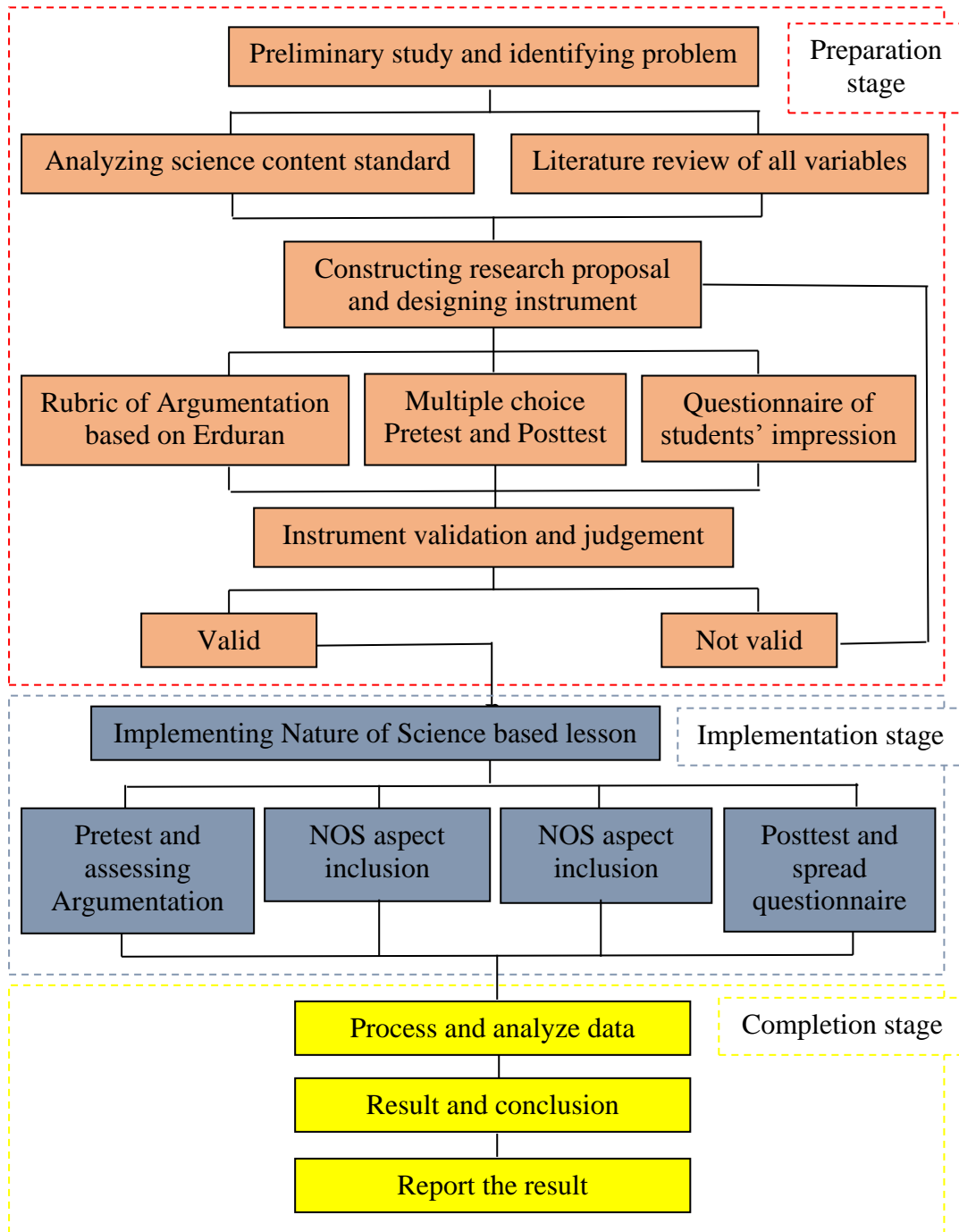
The research plot is described in the Figure 3.2.

Figure 3.2 Research Plot