CHAPTER III

RESEARCH METHODOLOGY

A. Location and Subject

1. Research Location and Period

The research was conducted at International School in Bandung, West Java that applied 2013 Curriculum during instructional process. Data is obtained in the period of May until June 2014.

2. Population and Sample

Population is defined as generalization consists of objects or subjects that cover whole quality and specific properties; meanwhile sample is a part of whole quality and specific properties of population (Sugiyono, 2008:118)

The population of this research is all of students' significance in conceptual change and cognitive learning outcomes that belongs to all secondary students in the school. Samplings are selected by purposive sample technique since researcher has the specific objective. The sample is all of students' significance in conceptual change and cognitive learning outcomes under the topic of light and optics that consists of 22 students of VIII Grade.

B. Research Method and Design

1. Research Method

Method that is applied in this research is weak experimental method since only one treatment group is investigated without the involvement of control group (Arikunto, 2010). There will be no control group since it is not appropriate to compare method of concept map construction using prototype-based media with traditional method. Qualitative analysis of students' conceptual change by

mapping the preliminary and post concept map is required in order to analyze its relation towards cognitive learning outcomes that is assessed quantitatively through statistical means; therefore mixed method is developed in this research. Research variables are classified into two; independent variable (X) and dependent variable (Y) that is affected by the treatment process. Five-stage conceptual teaching model by utilizing CmapTools is the independent variable, whereas the dependent variable is students' cognitive learning outcomes.

2. Research Design

Type of mixed method design that is applied in this research is convergent parallel that simultaneously collect both quantitative and qualitative data, merge the data and use the results to understand research problem. The datasets is analyzed separately based on its own indicator in order to make interpretation as to whether the results support or contradict each other that provides a convergence of data sources (Creswell, 2011).

Students' preliminary and post concept map will be analyzed qualitatively based on the scoring rubric that is developed by researcher and experts based on Novak's criteria (1984, in Karakuyu, 2010) including concept map pattern based on Kinchin (1999 in Hay and Adams, 2000). Concept elaboration of each individual that is developed can be analyzed descriptively based on comparison of preliminary and post concept map construction. Qualitative investigation is also concern on students' ability in linking concept node to various resources by utilizing *CmapTools* to understand their thinking process.

Quantitative analysis focuses on students' cognitive learning outcomes that is obtained from pretest and posttest result by statistical calculation in order to investigate achievement in each cognitive domain; from C1 (remembering) until C4 (analyzing).

The interpretation concerns on quantitative measurement of the correlation between conceptual change and cognitive learning outcomes in order to analyze whether significance conceptual change can affect great cognitive outcomes.

Figure 3.1 below represents the convergent parallel design for better understanding.

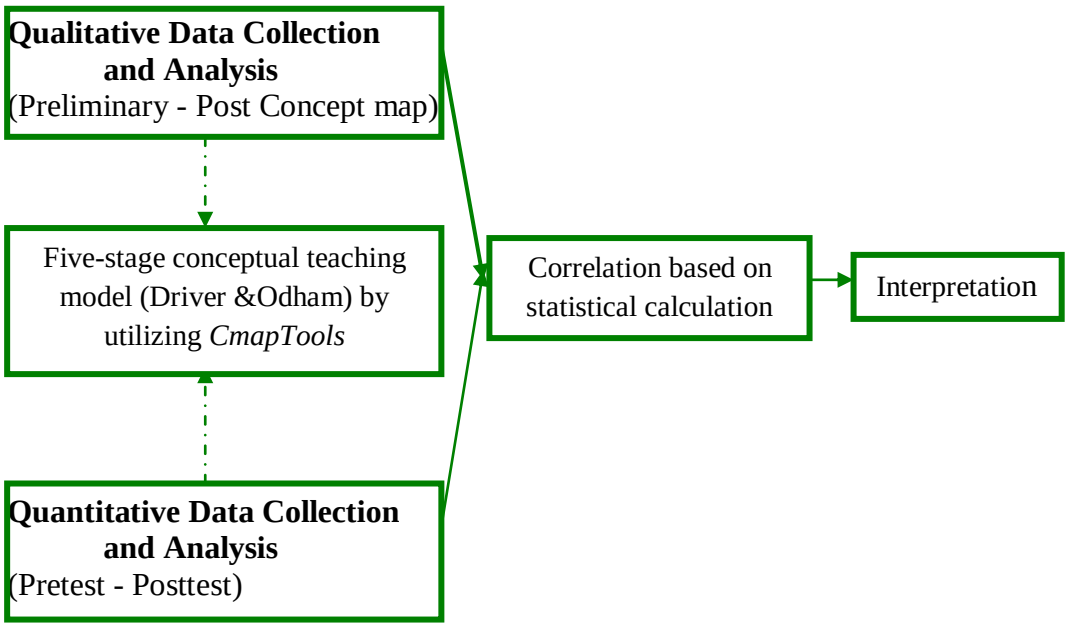

Figure 3.1 Type of Mixed Method Design; Convergent Parallel (Cresswell, 2012: 541)

C. Operational Definition

Operational definition is required in order to give the clarity of the research that has to be suitable with the expected aims; that described as follows:

1. Conceptual change is the significance change of students' conception in learning Light and Optics based on comparison of preliminary and post concept map construction that emphasizes on significance changing of concept map criteria intorelationship, hierarchical structure, cross link and specific example as well as significance changing of concept map structure into spoke, chain or netunder five stage conceptual teaching model consists of orientation, elicitation, restructure, application and review change of ideas.
2. Concept map is a visual set of concepts aims to answer focus question. According to Novak (1984) concept map is constructed under four elements;

such as (1) prepositions is the connection among concept node through the inclusion of meaningful an informative linking words that represents students' understanding, (2) hierarchical structure based on arrangement from inclusive to exclusive concepts represents concept organization and classification, (3) cross links is the interconnection among concepts in different map segments or domain represents mapping complexity and analysis ability, and (4) example of specific concept node represents concept application.

3. Cognitive learning outcomes is the competencies of students to achieve cognitive dimension after utilizing *CmapTools* that is determined from C1 (remembering) – C2 (understanding) – C3 (applying) and C4 (analyzing) in learning Light and Optics through pretest and posttest that consists of 25 multiple questions.
4. *CmapTools*that is used in this research is a prototype media developed by IHMC (Institute of Human and Machine Cognition) that aims to mapping students' conceptual change based on concept map construction. *CmapTools* has benefits to link concept node into various learning resources that is used for qualitative analysis to investigate students' visual learning.
5. Students' response towards *CmapTools* utilization is classified into four criteria such as; (1) impression of improvement in learning Physics,(2) interest and motivation towards Physics lesson, (3) improvement of behavior aspect towards Physics lesson, and (4) cognition towards the benefits of *CmapTools* feature.

D. Research Instrument

The research instrument that is applied for collecting data in this research consists of:

1. Significance of students' conceptual change is analyzed by using rubrics that consists of concept map scoring rubric (Table 3.6) under Novak and Gowin's criteria that aims to determine quantitative scoring based on four indicators

and concept map structure rubric (Table 3.7) that aims to analyze changing of map structure that is obtained from preliminary and post concept map construction.

2. Improvement of students' cognitive learning outcomes is analyzed by implementing objective test (Appendix B.1) in form of multiple questions with four distractors that is obtyained from pretest and posttest.
3. Students' response towards *CmapTools* utilization in learning Light and Optics is analyzed based on unstructured questionnaire form (Appendix B.2) that emphasizes on four indicator such as; (1)impression of improvement in learning Physics, (2) interest and motivation towards Physics lesson, (3) improvement of behavior aspect towards Physics lesson, and (4) cognition towards the benefits of *CmapTools* feature.

E. Instrument Development and Analysis

Research instruments development is initiated with the content analysis of 2013 curriculum that is used in school. Expert concept map as main reference for scoring students' concept map for investigating conceptual change has to be developed first by the researcher under suggestion from Physics expert (Appendix B.3). The expert concept map is formulated based on the applicable content that has to be suitable with the ability of secondary students.

The research instrument in order to measure secondary students' cognitive development has to be consulted by the lecturer and some experts in related field in order to modify or revise test items that are not appropriate with the content, distractors, or question statament. After being revised, the instrument will be tested and analyzed first before being used twice as pretest and posttest in the preliminary study. The objective tests will be tested to the group of students that has already given the topic of Light and Optics; therefore it will be tested into secondary level grade IX. Test was carried out to 25 students grade IX in private school Cirebon that apply integrated science with full English teaching in

accordance with the questions statement. The instrument analysis of objective test requires levels of difficulty, discriminating power validity and reliability.

1. Instrument Test Requirements

a. Level of Difficulty

Good quality question has to be arranged in balanced; the proportion should not consist of whole easy or hard questions, since easy question will not stimulate students to spend more effort in answering as well as hard questions will make students desperate and doesn't have any motivation to solve it (Arikunto, 2013: 222). Consideration of difficulty level is based on proportion of problem categories easy, medium and difficult. The formula to determine levels of difficulty is represented as follow:

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$$P = \frac{B}{JS} \quad \text{..... (3.1)}$$

Where:

P= difficulty level

B = number of students who answer correctly

N= Total number of students

(Arikunto, 2013: 224)

Classification of difficulty level based on Arikunto is represented on Table 3.1 as follow:

Table 3.1Interpretation of Difficulty Level

No.	Difficulty Value	Criteria
1.	0.00 – 0.30	Hard
2.	0.31 – 0.70	Middle
3.	0.71 – 1.00	Easy

(Arikunto, 2013: 225)

b. Discriminating Power

Discriminating power is defined as the ability of particular question to distinguish students who classified as higher achievement and lower achievement. The amount of higher achievement students who can answer more particular questions compared to lower achievement means that those questions have positive discriminating power index (Arikunto, 2013: 226). Discriminating power index shows the scale from minus one until positive one, with the negative represents lower discriminating power index and vice versa. The formula to determine the discriminating power is represented below followed by criteria as seen on Table 3.2

$$DP = \frac{Ba}{Ja} - \frac{Bb}{Jb} \quad \text{..... (3.2)}$$

Where:

DP = Discriminating Power

Ba = The number of upper group that answer correctly

Ja = Total of students in upper group

Bb = The number of upper group that answer incorrectly

Jb = Total of students in lower group

(Arikunto, 2013: 228)

Table 3.2Interpretation of Discriminator Power

No.	Discriminating Power Value	Criteria
1.	0.00 – 0.20	Poor
2.	0.21 – 0.40	Satisfactory
3.	0.41 – 0.70	Good
4.	0.71 – 1.00	Excellent

(Arikunto, 2013: 232)

c. Validity

Validity is defined as the extent to which the instrument measures what it is designed to measure that emphasizes not on the test itself, but on the result (Arikunto, 2013: 80). Validity which is used in this study is Construct Validity since each question item is formulated based on Cognitive Taxonomy. Arikunto (2013:83) describe construct validity measures thinking aspect based on logical; such as classified question item into cognitive dimension. The formula to determine validity is shown below followed by Table 3.3 that interprets the classification of coefficient correlation criteria.

$$r_{xy} = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{\{N \sum X^2 - (\sum X)^2\}\{N \sum Y^2 - (\sum Y)^2\}}} \quad \text{…….. (3.3)}$$

Where:

r_{xy} = coefficient correlation or item validity

$\sum X$ = sum of total score of all students for each question's item

$\sum Y$ = sum of total score of all students for whole test

N = total number of students

X = score of each student for each question's item

Y = total score of each student

(Arikunto, 2013: 87)

Table 3.3Interpretation of Validity

No.	Value r_{xy}	Criteria
1.	0,80 < r ≤ 1,00	Very High
2.	0,60 < r ≤ 0,80	High
3.	0,40 < r ≤ 0,60	Satisfactory
4.	0,20 < r ≤ 0,40	Low
5.	0,00 ≤ r ≤ 0,20	Very Low

(Arikunto, 2013: 89)

d. Reliability

Reliability is defined as the extent to which a questionnaire, test, observation or any measurement procedure produces the same results on repeated trials. In short, it is the stability or consistency of scores over time or across raters (Arikunto, 2013: 101). The split-half method using KR 20 equation is used to calculate reliability of the test by giving score one for correct answer and zero for wrong answer (Arikunto, 2013: 108).The equation is described as follow:

$$r_{11} = \left(\frac{k}{k-1}\right)\left(1-\frac{\sum pq}{s^2}\right) \quad \text{..... (3.4)}$$

Where:

r_{11} = instrument reliability

k = amount of test item

$\sum pq$ = multiplication result of p and q

s = deviation standard

The reliability interpretation represents on the table below.

Table 3.4Interpretation of Reliability

Reliability coefficient	Criteria
0.00 <r ≤ 0.20	Very low
0.20 <r ≤ 0.40	Low
0.40 <r ≤ 0.60	Satisfactory
0.60 <r ≤ 0.80	High
0.80 <r ≤ 1.00	Very high

(Arikunto, 2013: 109)

e. Recapitulation of Students' Cognitive Outcomes Instrument

Objective test for measuring students' cognitive learning outcomes in form of 30 questions has to be tested in terms of difficulty level, discriminating power, validity and reliability that are given to 25 students grade IX who already gained the material of Light and Optics before. Decision based on test requirement result can be used, dropped, or revised with experts related with the probability of particular question item to be used. The recapitulation of objective test as well as specification for each question item is represented on following table and Appendix C.3 for more distinct result.

Test item recapitulation :

Reliability test : 0. 81 (Very High)

Table 3.5Recapitulation of Test Item for Students' Cognitive Outcomes

Question Number	INSTRUMENT TEST RESULT						DECISION
	Difficulty Level	Category	Discriminating Power	Category	Validity	Category	
1	0.52	Medium	0.57	Good	0.61	High	Used
2	1	Easy	0.12	Poor	Undefined	Very Low	Dropped
3	0.67	Medium	0.42	Good	0.72	High	Used
4	0.44	Medium	0.67	Good	0.64	High	Used
5	0.84	Easy	0.14	Poor	0.13	Very Low	Dropped
6	0.52	Medium	0.54	Good	0.78	High	Used
7	0.67	Medium	0.38	Satisfactory	0.67	High	Used
8	0.70	Medium	0.43	Good	0.64	High	Used
9	0.28	Difficult	0.84	Excellent	0.45	Satisfactory	Used
10	0.67	Medium	0.57	Good	0.74	High	Used
11	0.28	Hard	0.27	Poor	0.21	Very Low	Dropped
12	0.52	Medium	0.67	Good	0.78	High	Used
13	0.28	Difficult	0.89	Excellent	0.67	High	Used
14	0.25	Difficult	0.84	Excellent	0.58	Satisfactory	Used
15	0.28	Difficult	0.89	Excellent	0.72	High	Used
16	0.52	Medium	0.67	Good	0.48	Satisfactory	Used
17	0.44	Medium	0.54	Good	0.58	Satisfactory	Used
18	0.67	Medium	0.43	Good	0.54	Satisfactory	Used
19	0.52	Medium	0.58	Good	0.58	Satisfactory	Used
20	0.28	Difficult	0.73	Excellent	0.47	Satisfactory	Used

21	0.52	Medium	0.48	Good	0.78	High	Used
22	0.67	Medium	0.77	Excellent	0.54	Satisfactory	Used
23	0.28	Difficult	0.74	Excellent	0.67	High	Used
24	0.44	Medium	0.48	Good	0.42	Satisfactory	Used
25	0.81	Easy	0.10	Poor	0.13	Very Low	Dropped
26	0.77	Easy	0.12	Poor	0.19	Very Low	Dropped
27	0.44	Medium	0.57	Good	0.78	High	Used
28	0.52	Medium	0.57	Good	0.53	Satisfactory	Used
29	0.67	Medium	0.71	Excellent	0.67	High	Used
30	0.52	Medium	0.87	Excellent	0.75	High	Used

2. Instrument Non-Test Requirements

a. Rubrics

Concept map scoring and concept map structure are two main rubrics that are applied in this research. Concept map scoring rubric is designed based on Novak and Gowin(1984) that covers four main elements such as preposition, hierarchical level, cross link and example that aims to analyse significance of conceptual change that is obtained from preliminary and post concept map construction. Concept map structure is adapted based on Kinchin and Hay (2000) that concern on the pattern of concept map into spoke, chain or net that represents the conceptual changing. Concept map scoring rubric is elaborated by the researcher and revised based on related experts' recommendation that utilizes scale to calculate students' concept map score compared to expert concept map.

b. Questionnaire

Questionnaire consists of twenty five positive statements and five negative statements is used to illustrate students' response towards *CmapTools*utilization in learning Light and Optics. Questionnaire is developed by researcher based indicators that emphasizes on students' impression of improvement in learning, behavior, cognition, interest and motivationtowards Physics lesson. Revision is conducted based on the consultation with experts related with the question statement that seems inappropriate or causing confusion.

F. Data Collection Technique

Qualitative and quantitative data that is obtained in this research requires different collection technique as well as scoring method. Qualitative data is obtained from preliminary and post concept map construction that empathizes on conceptual change based on significance changing of students' concept map scoring as well as concept map structure. Meanwhile quantitative data concern on cognitive learning outcomes emphasizes on changing in each cognitive level that is obtained from pretest and posttest. Data collection techniques are explained a follow:

1. Data of Students' Conceptual Change based on Concept Map Scoring

Students' conceptual change that is obtained from preliminary and post concept map construction is assessed by Concept map scoring rubric. Scoring based on Novak and Gowin (1984) such valid preposition is one, hierarchical structure is five, cross link is ten, and specific example is one for each meaningful mapping is used as maximum score. Each element is elaborated into four different criteria such as excellent-good-poor-and failing that aims to differentiate each student's concept map quality after whole preliminary and post concept map is collected. Scoring will be divided by four in order to indicate each indicator that represents different characteristics under discussion with experts.

Table 3.6Concept Map Scoring Rubric

Element	**SCORING ELABORATION**			
Preposi-tions	**Excellent (1)**	**Good (0.75)**	**Poor (0.50)**	**Failing (0.25)**
	Relationships between concepts are indicated by linking words that is true and informative which represents	Relationships between concepts are indicated by linking words that is true but not informative because	Relationships between concepts are indicated by linking words with several misconception occurs. The linking words	Relationships between concepts are Indicated or not by linking words that is wrong conception and not

	essential relationship that can be well understood.	readers already knew the essential information.	are arranged using many words but not informative.	informative or even not using The linking words cannot represent the relationship between each concept node.
Hierar-chical Levels	**Excellent (5)**	**Good (3.75)**	**Poor (2.5)**	**Failing (1.25)**
	Map includes the important concepts and describes domain on multiple levels which is arranged consistently from most general to specific concepts.	Map includes most important concepts; describes domain on limited number of levels which is arranged from most general concept with inconsistent in several structure such indication of generalization is made after concept is arranged specifically.	Important concepts missing and/or describes domain on only one level, the concept arrangement is mixed with many generalization occurs.	Map includes minimum concepts with many important concepts missing, the concept is not arranged from general to specific so it cannot represent meaningful mapping.
Cross Links	**Excellent (10)**	**Good (7.5)**	**Poor (5.0)**	**Failing (2.5)**
	Shows how a concept in one domain of knowledge represented on the map is related to a concept in another domain shown based on true, informative, indicates strong	Shows how a concept in one domain of knowledge represented on the map is related to a concept in another domain shown based on true but not informative since readers	Shows how a concept in one domain of knowledge represented on the map is not related to a concept in another domain due to several indications of misconcep-tion.	Shows how a concept in one domain of knowledge represented on the map is not related to a concept in another domain because of wrong conception.

	relationship based on conceptual knowledge.	already knew the information, indicates weak relationship.		
Specific Example	**Excellent (1)**	**Good (0.75)**	**Poor (0.5)**	**Failing (0.25)**
	The examples are more given as the application of each most specific node that clarify well the meaning of concept.	The examples are given as the application of each most specific node that cannot clarify well the meaning of concept and sometimes not related with the node.	The examples are less given as the application of each most specific node that sometimes misconception occurs based on the factual knowledge.	The examples are not given as the application of each most specific node that indicates wrong conception based on factual knowledge

2. Data of Students' Conceptual Change based on Concept Map Structure

Significance changing of concept map structure that is obtained from preliminary and post concept map structure represents well restructure of ideas that illustrate how students change their conception. Qualitative approach that aims to investigate concept map pattern for analyzing conceptual change is developed by Kinchin and Hay (2000: 48). They classified concept map structure into spoke, chain and net as seen on Figure 2.2.a, 2.2.b, and 2.2.c that emphasizes on hierarchy level, processes, complexity, conceptual development and representation as seen on Table 3.7 as follow:

Table 3.7Concept Map Structure Rubric

Aspect	**Map Type**		
	Spoke	**Chain**	**Net**
Hierarchy Level	One level only	Many levels with the inclusion of misconception or incorrect concept	Several justifiable levels
Processes	Simple association with no	Shown as a temporal sequence	Described as complex

	understanding of processes or interactions	with no complex interaction or feedback	interactions at different conceptual levels
Complexity	So little integration that concepts can be added without consequences for map integrity	Map integrity cannot cope additions, particularly near the beginning of the sequence	Map integrity is high. Adding one or more concepts has minor consequences as other routes through the map are available.
Conceptual Development	Shows little or no word view. Addition or loss a link has little effect on the overview.	Integrated into a narrow world-view, suggesting an isolated conceptual understanding. Loss of link can lose meaning of the whole chain.	Can support reorganization to emphasize different components to appreciate a larger world-view or to compensate for a missing link
Represents	National Curriculum Structure	Lesson Sequence	Meaningful Learning

3. Data of Students' Cognitive Learning Outcomes

Students' cognitive learning outcomes in each cognitive level are obtained two times based on pretest and posttest. Test is carried out with the form of multiple choices using 25 test items under the topic of Light and Optics. Objective test is formulated based on factual and conceptual knowledge in the form of multiple choices using four options with the cognitive dimension as C1 (remembering), C2 (Understanding), C3 (Applying), and C4 (Analyzing). The blueprint of the objective test is shown based on table 3.8 below represents proportion for each cognitive level.

Table 3.8Blueprint of Objective Questions

No	Subtopics	Learning Objective	Specification			
			C1	C2	C3	C4
1.	**Properties of Light**	Correlate the properties of light that propagates in		1		

		straight line based on daily life phenomena				
		Determine that light which is emitted by stars is classified aselectromagnetic wave.		2		
2.	**Reflection of Light**	Determine the form of diffusion reflection on the rough surface using diagram.		3		
		Interpret concept of Law of Reflection and image formation in plane mirror	4,5			
		Apply geometrical optic formula in curved mirror			11,12	
		Analyze nature of image formation in curved mirror				13,14, 15
		Exemplify the principle of curved mirror in daily life phenomena	16	10		
3.	**Refraction of Light**	Correlate the principle of light refraction indaily life phenomena		6,7		
		Determine ray between two mediums with different density based on Snell's Law		8		
		Analyse the form of refraction using ray diagram based on refraction index				9
		Apply geometrical optic formula in lenses			18,19, 21,22	
		Analyse nature of image formation in lenses				20,23
		Exemplify the principle of lenses in daily life phenomena		17,24, 25		
Total			3	10	6	6
Percentage			12%	40%	24%	24%

4. Data of Students' Response

Non-test data instrument using questionnaire is implemented to investigate students' response towards *CmapTools*utilization in learning Light and Optics. Questionnaire is developed under four main indicators such as; (1) impression of improvement in learning Physics,(2) interest and motivation towards Physics

lesson, (3) improvement of behavior aspect towards Physics lesson, and (4) cognition towards the benefits of *CmapTools* feature. There are 25 statements with the inclusion of 5 questions that states negative statement in order to control students' answer. This attitude scale uses Likert with four points of type scale (absolutely agree, agree, do not agree, absolutely do not agree) based on Measurement of Successive Interval (MSI) computation. Type of scale which states do not agree is prevented in order to make the clarity of student's response after experiencing *CmapTools*. Scoring of positive statement is given point 5 until 1 orderly from strongly agree until strongly disagree criteria; whereas scoring of negative statement is vice versa. The blueprint is represented based on Table 3.9 as follow:

Table 3.9Blueprint of Students' Response Questionnaire

No.	Indicator	Properties	Statement Numbers
1.	Students' impression of improvement in learning Physics after experiencing *CmapTools*	Positive	1,6,11,16,21
		Negative	5
2.	Students' interest and motivation in learning Physics after experiencing *CmapTools*	Positive	2,7,12,17,22
		Negative	10,25
3.	Students' improvement of behaviour aspect towards Physics lesson after experiencing *CmapTools*	Positive	3,8,13,18,23
		Negative	15
4.	Students' cognition towards the utilization of *CmapTools*feature	Positive	4,9,14,19,24
		Negative	20

G. Data Processing and Analysis

Quantitative and qualitative data that is obtained in this research will be processed in different method of calculation. Qualitative data emphasizes on significance of students' conceptual change from preliminary and post concept map construction including students' response towards *CmapTools* utilization, whereas quantitative data obtained from pretest and posttest emphasizes on improvement of cognitive learning outcomes after *CmapTools* is utilized. Calculating data procession will be explained as follow:

1. Data Processingof Students' Conceptual Change

Students' concept map that is obtained twice in preliminary and post implementation in order to illustrate significance of conceptual change will be assessed based on concept map scoring rubric (Table 3.6). Expert concept map that is already developed by researcher together with Physics expert is used as maximum score. Concept map scoring isrepresented as follow including the score interpretation on Table 3.10.

$$Concept\ Map\ Score = \frac{actual\ \ cmap\ \ score}{maximum\ \ \ cmap\ \ score\ \ (\ Expert\ \ Cmap\ )}\ x\ 100\% \quad \ldots\ldots\ (3.5)$$

Table 3.10Concept Map Scoring Interpretation

No.	Score	Criteria
1.	81% - 100%	Very High
2.	61% - 80%	High
3.	41% - 60%	Medium
4.	21% - 40%	Low
5.	0% - 20%	Very Low

(Syah, 1999 in Sairan, 2008:40)

2. Data Processingof Students' Cognitive Learning Outcomes

Objective test that consists of 25 multiple questions based on arrngemet of cognitive level from C1 (remember) until C4 (analysing) will be assessed based on scoring. For each correct answer will be given score 1 whereas wrong answer will be given score 0.Scores then will be converted into 0-100 scale value.The score conversion in form percentage (%) represents based on this equation:

$$Student's\ score\ (\%) = \frac{total\ \ right\ answer}{Maximum\ \ \ score} x\ 100\% \quad \ldots\ldots\ldots\ldots\ (3.6)$$

Table 3.11Category Scale of Students' Score

Score	Category
$S \leq 40$	Very poor
$41 \leq S \leq 55$	Poor

56 ≤ S ≤ 65	Satisfactory
66 ≤ S ≤ 80	Good
81 ≤ S ≤ 100	Excellent

(Arikunto 2013: 281)\

Gain score (actual gain) was obtained from the difference of pre-test score and post-test score. The difference in pre-test scores and the post-test is assumed as the effect of the intervention. Normalized gain calculations are intended to determine the categories of students' achievement improvement. According to Hake (1999) normalized gain is calculated by using this following formula:

$$G = S_f - S_i \qquad \text{..... (3.7)}$$

(Hake, 1999)

Where :

G = Gain

S_f = Post-test score

S_i = Pre-test score

The improvement of cognitive learning outcomes in learning Light and Opticsafter utilizing *CmapTools*for constructing concept maps will be seen from the result of the normalized gain that achieved by students. For the calculation of the normalized gain value and its classification will use equations as follows:

$$< g >= \frac{\%G}{\%Gmax} = \frac{(\%S_f - \%S_i)}{(100 - \%S_i)} \qquad \text{..... (3.8)}$$

Where:

<g> = Normalized gain

G = Actual gain

Gmax = Maximum gain possible

Sf = Post-test score

Si = Pre-test score

(Hake, 1999)

The value of <g> is determined based on criteria below on the table below:

Table 3.12Criteria of N Gain Improvement

N-Gain <g>	Improvement Criteria
0,00 – 0,29	Low
0,30 – 0,69	Medium
0,70 – 1,00	High

(Hake, 1999)

3. Data Processing of Students' Response towards *CmapTools* Utilization

Qualitative analysis of students' response is carried out in order to analyze students' interest, motivation, impression and cognition towards the implementation of using *CmapTools* in constructing concept map. 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 3.13 as follow:

$$\text{Score} = \frac{Raw\ Score}{Maximum\ Score} \text{ x } 100\% \quad \text{..... (3.9)}$$

(Arikunto, 2013: 262)

Table 3.13Scoring Guideline of Students' Response

	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
Negative Statement	5	4	3	2	1
Positive Statement	1	2	3	4	5

(Sugiyono, 2008: 203)

The interpretation of score percentage is categorized into certain criteria according to Arikunto (2013) is represented as follows.

Tabel 3.14Percentage Interpretation of Questionnaire

Percentage(%)	Criteria
0%	None
0 %- 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, 2013: 263)

4. Data Analysis and Hypothesis Test

a. Normality Test

Parametric statistic is implemented in this research since it aims to measure the parameter of particular sample that has normal distribution. If the distribution is free, non-parametric statistic is used. Parametric statistic is more valid and powerful compared to non-parametric related with interval and ratio data; if the assumptions are reasonably met (Phopan, 1973 in Sugiyono, 2008: 211). Normality test is executed in order to analyze whether samples comes from population that has normal distribution or not. SPSS version 17.0 is used as supporting software to determine normality test for each pretest and posttest based on Kolmogorov-Smirnov. Data is considered as normal distribution if the criterion is higher than assumption of significance in two-tailed.

b. Hypothesis Test

Hypothesis test is measured based on Pearson correlation product moment by utilizing SPSS version 17.0. Since in this research the hypothesis arrangement emphasizes on the significance correlation between conceptual change based on *CmapTools* utilization and cognitive learning outcomes, it is classified as associative hypothesis (Sugiyono, 2008 : 236). Correlation value that is obtained will be compared to Pearson product moment table at significance 5%. Alternative hypothesis will be accepted if the calculated correlation coefficient is higher than correlation coefficient from table; or represented as: r_{xy}calculated >r_{xy}table and is vice versa for the null hypothesis acceptance. The interpretation of correlation coefficient is developed by Sugiyono in this table as follow:

Table 3.15Interpretation of Correlation Coefficient

Correlation coefficient (r_{xy})	Interpretation
0,0 – 0,19	Very low
0,20 – 0,39	Low
0,40 – 0,59	Medium
0,60 – 0,79	Strong
0,80 – 1,00	Very strong

(Sugiyono, 2008: 257)

Determination coefficient can be calculated in order to determine the regression equation as represented by the equation as follow:

$$R = (r^2) \times 100\% \quad \text{..... (4.0)}$$

Where:

R = Determination coefficient

r = Correlation coefficient

(Sugiyono, 2008: 259)

Regression analysis aims to obtain the equation that is used to investigate the prediction of high or low dependent variable value (Y) if the independent variable is being modified or manipulated (Sugiyono, 2008: 261). The equation is represented as follow:

$$Y = a + b\,X \quad \text{..... (4.1)}$$

Where:

Y = Value that will be predicted

a=Constanta or if the X value is zero

b = Regression coefficient

X = Value of independent variable

(Sugiyono, 2008: 259)

H. Research Procedure

This research is carried out into three stages; preparation, implementation and final stage under conceptual change teaching model according to Driver and Oldham. The stage description will be explained as follows:

1. Preparation stage

In the planning stages consists of preliminary study, literature study, and design the research instrument.

a. Preliminary Study

Preliminary study aims to identify the problem in real Physics classroom environmental system. It is useful to find out obstacles which students faced, so questionnaires have to be distributed. A questionnaire consists of ten questions is given to each student one week before entering the lesson stage. Teacher also are being interviewed about several problems that she faced during teach physics. By analyzing the results of both questionnaires and teacher's interview, research problem can be formulated.

b. Literature Review

Reviewing essential theories from trusted recourses is necessary to support the research implementation. Research variables will be discussed in the literature review such as conceptual change including how to develop the teaching model, concept map construction, cognitive learning outcomes based on Anderson's and Krathwohl'sTaxonomy, students' response towards *CmapTools* utilization during instructional process as well as previous studies regarding with this research. The core competences as well as basic competences of Curriculum 2013 and learning topic of Light and Optics will also be reviewed for lesson plan arrangement.

c. Research Instrument Design

Research instrument is designed as quantitative and qualitative instrument into test and non-test. Non-test instrument such as concept map scoring rubric under Novak and Gowin's criteria; preposition, hierarchical level, cross links and examples is developed by researcher together with the related experts as well as adoption of concept map structure rubric based on Kinchin. Researcher also has to developed expert concept map as maximum score to assess students' concept map based on recommendation of lecturer and supervisors. Questionnaire is developed using Likert scale under four indicators such as (1) impression of improvement in learning Physics,(2) interest and motivation towards Physics lesson, (3) improvement of behavior aspect towards Physics lesson, and (4) cognition towards the benefits of *CmapTools* feature. Test instrument emphasizes onobjective tests that has to be judged first based on discriminator power, level of difficulty, reliability, and validity using Ms. Excel computation before distributing the questions to the treatment group. Researcher also has to concern with the role of *CmapTools* to utilize students in constructing concept map during Light and Optics so several features has to be optimized first.

2. Implementation Stage

Research implementation is explained as follow:

a. Experimental class determination based on purposive sampling.
b. Pretest implementation in order to describe students' prior conception.
c. Processing pretest result.
d. Conduct research activity by implementing conceptual change teaching model based on Driver and Oldham (1986 in Lin et. al., 2010) under following scenarios:
    1) First meeting emphasizes on orientation and elicitation of ideas stage. Orientation confirms the direction of investigation that helps students understand the goal of the course by, presenting videos and interactive flash related with focus questions how light behaves as well as being reflected and refracted. Elicitation of ideas emphasizes on how

students report their prior knowledge in order to investigate their prior conception through preliminary concept map construction by answering how light behaves, how light is reflected and refracted as focus question using conventional method or handwriting. Concept Text is used as assistant to helps students elaborate their prior conception.Before constructing preliminary mapping, concept map introduction based on Novak's criteria into preposition, hierarchical level, cross links, and examples. Preliminary discussion together with students is conducted first to make them realize the differences between concept map and mind map that is usually made. This session also concerns how to construct concept map by classifying and organizing general to specific concepts including linking words formulation to connect each concept node.

2) Second meeting emphasizes on restructure of ideas that is elaborated into first sequence of clarification and exchange based on small group discussion in order to examine and criticize of others' prior conception related with focus question that is proposed by teacher; *"How you can see the twinkling of stars in the night which is really bright? How the light can propagate to your eyes though the hole of roof in your house?How is the image that you see if you use the inner part of spoon and the outer part of spoon? How come a pencil can be bent inside a glass of water?"*Flow of discussion will be monitored by teacher in order to prevent meaningless explanation that seems out of topic. Discussion result will be inputted by teacher. Second sequence isexposure to conflict situation concerns on learning activity based on interactive demonstration of light propagates in straight line using three blackboards with hole in the centerand how nature ofimage formation is different if inside part as well as outer part of spoon is used. Demonstration also emphasizes on principle of light refraction through different medium density as seen as reverse image using paper craft and beaker glass that is filled with water. Experiment focus on law of

reflection principle including specular and diffuse reflection in order to make students investigate whether the value of angle formation between incident and reflected ray is same or not using laser, plane mirror, rough aluminum, and arc. Experiment also focus on Snell's law of refraction by using laser and two baker glasses that is empty and filled with water. Students have to determine the path of refraction in different medium density.

3) Third meeting still emphasizes on restructure of ideas phase that is elaborated into sequence of construction of new ideas and evaluation. Students are guided how to draw ray tracing diagram based on light reflection and refraction through teacher demonstration using laser, curved mirror and lenses. Students also are guided how to determine image distance, height and magnification by applying geometrical optic formula as well as nature of image formation analysis based on ray tracing diagram. Evaluation focus to solve problems under small group discussion.
4) Fourth meeting emphasizes on application of ideas by utilizing *CmapTools*. Teacher introduce *CmapTools*' feature such making connection to various resources. Students are guided first to classify and organize concepts from general to specific; then they have to consider meaningful linking words by connecting concept node as preposition. Students also have to correlate concepts in different domain by analyzing the similarities as well as connection under geometrical formula. Students are given time to construct post concept map by utilizing *CmapTools*based on their own thinking process. Review change in ideas is the next sequence conducted by teacher to analyze conceptual change for each individual by comparing preliminary and post concept map using concept map scoring rubric as well as investigation of concept map structure. Analyzing the validity of resources that is used by students is necessary to investigate the process of visual learning.

e. Posttest implementation to analyze gain in each cognitive level.
f. Questionnaire distribution to investigate students' response towards *CmapTools* utilization.

3. Final Stage

Final stage consists of data processing, data analysis, inferring and final report making. Deeper analysis how significance of students' conceptual change towards cognitive learning outcomes will be discussed based on statistical method and valid literatures. Recommendation for further research is also arranged to produce better research outcome in the future

I. Research Scheme

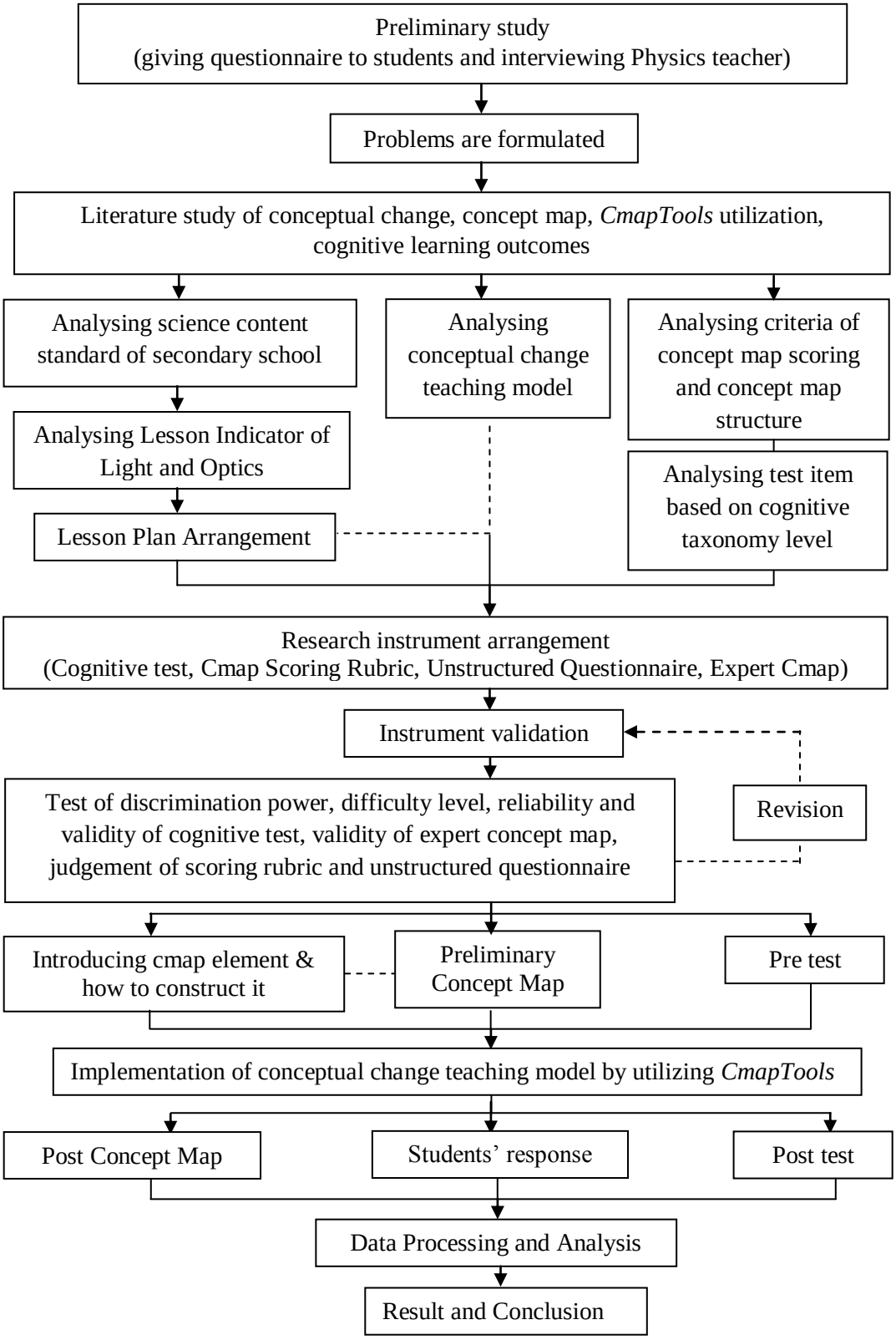

Figure 3.2 Diagram of Research Scheme