

## **Effects of Concept - Mapping Strategy on Reflective Thinking and Academic Performance in Mole - Concept Among Secondary School Chemistry Students, Kaduna State, Nigeria**

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### **Abstract**

The study investigated effects of concept - mapping strategy on reflective thinking and academic performance in mole - concept among secondary school chemistry students in Kaduna state, Nigeria. Quasi-experimental research design specifically, pretest posttest non-randomized control group design was adopted for the study. 643 (372 male & 271 female) senior secondary class two (SSII) Chemistry students in Giwa educational zone, Kaduna state forms total population of study. A sample size of 76 (46 Male & 30 Female) SSII students using an intact class of 2 out 14 school selected using Simple random sampling technique by balloting technique. The experimental group were taught Mole concept using concept-mapping strategy while control group were taught same concept using lecture method, respectively. Two instruments used for data collections; Mole Concept Performance Test (MCPT) and Reflective Thinking Questionnaire (RTQ), respectively. The instruments were validated by chemistry and science education experts, respectively. The MCPT and RTQ gave a reliability coefficient of 0.89 and 0.81 using Pearson Product Moment Correlation coefficient and Cronbach Alpha, respectively. Descriptive statistics was used to answer

research questions while t-test and Mann-Whitney U test were used to test hypotheses at 0.05 level of significance. Result obtained revealed that students in experimental group performed significantly better than those in control group on academic performance and level of reflective thinking, respectively. Based on findings of this study it was recommended among others that chemistry teachers should be trained and encouraged by Science Teachers Association of Nigeria (STAN) to use concept-mapping strategy in teaching chemistry so as to improve the academic performance of students.

### **Introduction**

Chemistry is one of the science subjects taught in Nigeria secondary schools and a major requirement for admission into science based programs such as Medicine, Engineering, Agriculture, Pharmacy, Biochemistry and Geology. This implies that Chemistry serve as a veritable tool for growth and development of any nation. Despite the importance of Chemistry, the West African Examination Council (WAEC) Chemistry result revealed an increase in failure rate from 49% to 59% with corresponding decrease in pass rate from 61% to 49% respectively between 2013 to 2018 academic session (Yakubu, 2019). These have become a major cause of concern to the government, science educationists and other stakeholders to identify the cause of poor result in chemistry with a bid to find lasting solution.

The chief examiner's report for the West African Senior School Certificate Examination (WASSCE, 2010-2018) pointed out that some of the reasons for candidates' poor performance in chemistry are; inability of the students to tackle most of the numerical questions in electrolysis, Redox Reactions, Qualitative analysis, mass-volume relationship; poor expressions; use of nomenclature especially in organic compound; deficiency in writing chemical formulae, incorrect balanced chemical equations. Interestingly, each of these concepts pointed out are rooted from mole concepts. In addition, (Dun, 2005 & Anthony, 2009) revealed that topics such as Electrolysis, Balanced Chemical Equation, Redox

Equations, Stoichiometry and Quantitative analysis are difficult for students to comprehend because they require basic knowledge of mole concept to understand. Also according to Bamidele, Adetunji, Awodele and Irinoye (2013) stated that the Students were observed to be deficient in the use of the Mole Concept and its application to Stoichiometry. Thus, various research findings have linked the cause of students' difficulty in mole concept to quality and quantity of instructional strategy used during Chemistry instructions (Olorukooba, 2001; Eniayeju, 2002; Danjuma, 2005; Novak & Canas, 2008).

Chemistry educators such as Olorukooba (2001) in Dahiru, (2013) revealed that about 80% - 90% of the scientific information or principles chemistry students received from their teachers are through lecture method. Thus, have little or no significant impact in improving students' achievement and retention in mole concepts, because they are abstract in nature and can best be taught using activity base method which is 'Hands on' 'minds on'. Moreover, Eniayeju (2002) also pointed out that the use of concrete materials facilitates better and proper understanding of concepts in chemistry. However, effective strategies designed to promote efficient and meaningful learning have been found to rely upon connecting prior knowledge to new concepts such as concept - mapping (Carol, 1998; Novak & Canas, 2008).

Concept-mapping is a diagrammatical representation of concepts connected by a linking word to represent relationship between pair of concepts. Bamidele *et. al* (2013) defined Concept maps as two or three - dimensional spatial or graphical displays that make use of labeled nodes to represent relationship between pairs of Concepts. Concept maps have been found to be a useful classroom tools for observing nuances of meaning, helping students organize their thinking and summarizing subjects of study and a growing body of research indicates that the use of concept maps could improve students' academic performance and reflective thinking in mole concept (Canas, Hill, Granados & Perez, 2003).

Academic Performance refers to as the level of individuals' growth in a test when compared with the scores of others at

the same level (Achino, 2012). Reflective thinking is a process in which an individual actively, consistently and carefully analyze and evaluate situation when relating it to ones' previous knowledge. The issue of gender needs to be investigated since gender is socio - cultural and built based on biological expectations of an individual on the basis of being a male or female (Peter & Samuel, 2013). It refers to a set of assumptions about the nature and character of biological differences between males and females, assumptions that manifest in a number of ideas and practices that have a determinant influence on identity, social opportunities and life experiences of human actors (Taylor, 1999).

Various research findings have revealed divergent opinions on effects of concept mapping instructional strategy on academic Performance and very little on reflective thinking. Some research findings on effects of concept mapping instructional strategies on academic Performance and reflective thinking in selected concepts in Chemistry revealed that there is a significant difference between students taught Chemistry using Concept mapping instructional strategy and those exposed to lecture method (Larbi, 2011; Otor, 2013; Cheema & Mirza, (2013) & Jack, 2014). Also research findings of Yakubu (2016) shows that there is no significant difference between academic Performance and reflective thinking of students taught mole concept in Chemistry using Concept mapping instructional strategy and those exposed to lecture method.

However, some research findings on impacts of concept mapping strategies on academic Performance and reflective thinking in selected concepts in Chemistry on gender revealed that there is a significant difference between male and female students taught Chemistry using Concept mapping strategy and those exposed to lecture method (Cheema & Mirza, 2013). While Otor (2013), Chawla (2015) & Yakubu (2016) shows that there is no significant difference between male and female students taught selected concepts in Chemistry using Concept mapping instructional strategy on both academic Performance and reflective thinking and those students taught using lecture method.

Thus, based on divergent opinions among science educationist, the study aims to determine effect of concept mapping strategy on reflective thinking and academic performance among male and female secondary school students in mole concept. In view of this aim that the study investigated effects of concept - mapping instructional strategy on reflective thinking and academic performance in mole concept among secondary school chemistry students in Giwa educational zone, Kaduna state.

### **Research Questions**

The following research questions guided the study:

1. What is the difference between mean scores of Chemistry students taught Mole - Concept using Concept – Mapping instructional strategy and those taught using lecture method?
2. What is the difference between mean scores of male and female Chemistry students taught Mole - Concept using Concept – Mapping instructional strategy?
3. What is the difference in students reflective thinking mean rank between those taught Mole - Concept using Concept – Mapping instructional strategy and those exposed to lecture method?
4. What is the difference between reflective thinking exhibited by male and female Chemistry students taught Mole - Concept using Concept – Mapping instructional strategy?

### **Research Hypotheses**

The following research hypotheses were tested in the study;

- Ho<sub>1</sub>. There is no significant difference between mean scores of Chemistry students taught Mole - Concept using Concept – Mapping instructional strategy and those exposed to lecture method.
- Ho<sub>2</sub>. There is no significant difference between mean scores of male and female Chemistry students taught Mole - Concept using Concept – Mapping instructional strategy.

Ho<sub>3</sub>. There is no significant difference in students reflective thinking mean rank between those taught Mole - Concept using Concept – Mapping instructional strategy and those exposed to lecture method.

Ho<sub>4</sub>. There is no significant difference between reflective thinking exhibited by male and female Chemistry students taught Mole - Concept using Concept – Mapping instructional strategy.

### **Methodology**

Quasi Experimental Research Design; Pretest - Posttest non – equivalent and non-randomized control group design was adopted for this study. The design is considered suitable for this study due to the fact that intact classes were used to avoid disruption of normal class lessons or activities. 643 (372 Male & 271 Female) Class II Chemistry students of 2015/16 academic session in Giwa educational zone of Kaduna state makes up population of the study. A sample size of 76 (46 male and 30 female) Chemistry students of 2015/16 academic session were used for the study using an intact class. Mole Concept Performance Test (MCPT) and Reflective Thinking Questionnaire (RTQ) were instruments used to collect data for this study.

Twenty-five (25) multiple choice questions option A - D were generated on mole concept using a table of specification for the MCPT while the Reflective Thinking Questionnaire (RTQ) developed by Kember, Leung, Jones, Loke, McKay, Sinclair, Tse, Webb, Wong and Yeung (2000) was adapted in this study. It contains 16 items descriptive of four scales of reflective thinking (habitual action, understanding, reflection and critical reflection) on a 5 point likert scale of Strongly Agree, Agree, undecided, Disagree and Strongly Disagree, respectively. Positive statements were scored 1, 2, 3, 4 and 5 while negative statement were scored in reverse order, respectively. The MCPT and RTQ were validated by Chemistry and Science Education experts as recommendations and suggestions pointed out were taken to improve the instruments. The split-half technique was used to test reliability of MCPT and Cronbach for RTQ among

49 class II 2015/16 academic session Chemistry students of GGSS Samaru, Kaduna State. Thus, the school was chosen because it shares the same characteristic with population of students. The MCPT and RTQ gave reliability coefficient  $r$  of 0.89 and 0.81 using Pearson product moment correlation coefficient and Cronbach alpha test respectively. This makes the instruments suitable and reliable for this study.

The students in both groups (Experimental and Control) were pretested before treatment and post tested after the treatment. During data collection, the experimental group were taught mole concept using concept mapping strategy while control groups were taught same concept using lecture method respectively. The MCPT and RTQ were then administered to the students to measure academic performance and reflective thinking in mole-concept respectively. Data collected were analyzed using mean and standard deviation to answer research question,  $t$ -test and Mann-Whitney  $u$ -test to test the 4 null hypotheses at 0.05 level of significance using Statistical Package for Social Sciences (version 23.0), respectively. The research period lasted for 6 weeks.

## Results

### Research Question One

What is the difference between performance of Chemistry students taught Mole - Concept using Concept - Mapping instructional strategy and those exposed to lecture method?

**Table 1:** Mean and Standard Deviation summary scores of groups on achievement scores

Group	N	X	SD	MD
Experimental	37	67.36	14.17	10.97
Control	39	56.36	12.37	

Table 1 revealed that experimental and control group had a mean score of 67.36 and 53.66, respectively with a mean

difference of 10.97 which favors experimental group. This means that concept mapping enhances students' academic performance in Chemistry. To find out how significant the difference is, t – test statistics was used to analyzing the scores.

**Null Hypothesis One**

H<sub>01</sub>. There is no significant difference between mean scores of Chemistry students taught Mole - Concept using Concept – Mapping instructional strategy and those exposed to lecture method?

**Table 2:** Posttest t-test of Experimental and control group based on academic performance

Group	N	Mean	STD	S. Error Mean	df	t.cal	t.crit	p-value
Experimental	37	67.36	14.17	2.16		74	4.20	0.02*
Control	39	56.39	12.37	2.06				

\* Significant at P  $\hat{A}$  0.05 level

Table 2 revealed that p value of 0.02 is significant at 0.05 level of significance. Hence, null hypothesis 1 is there by rejected. Therefore, concept-mapping strategy is more effective in improving students' performance than the lecture method.

**Research Question Two**

What is the difference between performance of male and female Chemistry students taught Mole - Concept using Concept – Mapping instructional strategy and those exposed to lecture method?

**Table 3:** Mean and Standard deviation summary scores of groups on achievement and gender



Gender	N	X	SD	MD
Male	19	37.71	2.34	0.35
Female	18	38.06	2.37	

Table 3 revealed that male and female group had a mean score of 37.71 and 38.06, respectively with a mean difference of 0.35 which favors female group. This shows that female students achieved higher than the male students. To find out if the value is significant, t – test statistics was used.

### Null Hypothesis Two

H<sub>0</sub>: There is no significant difference between mean scores of male and female Chemistry students taught Mole - Concept using Concept – Mapping instructional strategy?

**Table 4:** Posttest t-test of the performance of Experimental group according to gender

Group	N	Mean	STD	S.ErrorMeandf	t.cal	t.crit	p-value
Male	19	37.71	2.34	1.16	35	0.54	2.04 0.93
Female	18	38.06	2.37	1.19			

Not Significant at P  $\tilde{A}$  0.05 level

Table 4 revealed that p value of 0.93 is not significant at 0.05 level of significance. Hence, null hypothesis 2 is there by retained. Therefore, male and female students performed equally the same when taught mole concept using concept-mapping strategy.

### Research Question Three

What is the difference between reflective thinking of Chemistry students taught Mole - Concept using Concept – Mapping instructional strategy and those exposed to lecture method?

**Table 5:** Mean and Standard deviation summary scores of groups on reflective thinking

Group	N	X	Sum of Rank	MD
Experimental	37	68.42	1261	10.10
Control	39	58.32	872	

Table 5 revealed that experimental and control group had a mean score of 68.42 and 58.32, respectively with a mean difference of 10.10 which favors experimental group. This means that concept mapping enhances students' reflective thinking in Chemistry. To find out how significant the difference is, the scores were subjected to Mann-Whitney U-test statistics.

**Null Hypothesis Three**

Ho3. There is no significant difference in students reflective thinking mean rank between those taught Mole - Concept using Concept – Mapping instructional strategy and those exposed to lecture method?

**Table 6:** Mann-Whitney U-test analysis of Reflective Thinking level of Students in Experimental and control groups.

Group	N	Mean Rank	Sum of Rank	Mann-Whitney	p-value
Experimental	37	68.42	1261	32	0.05
Control	39	58.32	872		Sig*

\*Significant at P d'' 0.05 level

Table 6 revealed that p value is equal to 0.05 which implies p value as being significant thereby null hypothesis 3 was rejected. Thus, there is significant difference in reflective thinking of students taught using concept mapping strategy and those exposed to lecture method. Therefore, concept – mapping strategy is more effective in improving students' reflective thinking than the lecture method

#### Research Question Four

What is the difference between reflective thinking of male and female Chemistry students taught Mole - Concept using Concept-Mapping instructional strategy and those exposed to lecture method?

**Table 7:** Mean and Standard deviation summary scores of groups on reflective thinking and gender

Gender	N	X	Sum of Rank	MD
Male	19	47.86	974	0.19
Female	18	48.05	1102	

Table 7 revealed that male and female group had a mean and sum rank score of (47.86, 48.05) and (974, 1102), respectively with a mean rank difference of 0.19 which favors female group. This shows that female students achieved higher than the male students. To find out how significant the difference is, Mann-Whitney U-test statistics was used.

#### Null Hypothesis Four

Ho<sub>4</sub>. There is no significant difference between reflective thinking exhibited by male and female Chemistry students taught Mole - Concept using Concept – Mapping instructional strategy?

**Table 8:** Mann-Whitney U-test of Students Reflective Thinking According to Gender in the Experimental Groups

Group value	N	Mean Rank	Sum of Rank	Mann-Whitney	p-value
Male	19	47.86	974	44	0.72
Female	18	48.05	1102	NS	

### Summary of Findings

The following were summary of findings for this study

1. There is significant difference between mean scores of Chemistry students taught Mole - Concept using Concept - Mapping instructional strategy and those exposed to lecture method in favor of those exposed to concept mapping strategy.
2. There is no significant difference between mean scores of male and female Chemistry students taught Mole Concept using Concept-Mapping instructional strategy.
3. There is significant difference in students reflective thinking mean rank between those taught Mole Concept using Concept - Mapping instructional strategy and those exposed to lecture method in favor of those exposed to concept mapping strategy.
4. There is no significant difference between reflective thinking exhibited by male and female Chemistry students taught Mole - Concept using Concept – Mapping instructional strategy?

### Discussion of Findings

What is the difference between reflective thinking and academic performance on Chemistry students taught Mole - Concept using Concept – Mapping instructional strategy and those exposed to lecture method? There is significant difference between Chemistry students taught Mole - Concept using Concept – Mapping instructional strategy on Secondary School

Students reflective thinking and academic performance in mole concept and those exposed to lecture method in favor of those exposed to concept – mapping strategy. This agrees with the findings of (Larbi, 2011; Otor, 2013 & Jack, 2014) on effects of Concept Mapping Instructional strategies on achievement and Retention in selected concepts in Chemistry, which revealed that there is a significant difference between students taught selected concept in Chemistry using Concept mapping instructional strategy on reflective thinking and academic performance and those exposed to lecture method. But disagrees with (Cheema & Mirza, 2013) which shows that there is no significant difference between students' academic performance when taught selected concept in Chemistry using Concept-mapping instructional strategy and those exposed to lecture method.

What is the difference between reflective thinking and academic performance of male and female Chemistry students taught Mole - Concept using Concept – Mapping instructional strategy and those exposed to lecture method? There is no significant difference between Chemistry students taught Mole - Concept using Concept - Mapping instructional strategy on secondary school male and female students' reflective thinking and academic performance in mole concept. This disagrees with the findings of Kolawole (2002) and Cheema & Mirza (2013) on Impacts of Concept Mapping Instructional strategies academic performance in selected concepts in Chemistry on gender, which revealed that there is a significant difference between male and female students taught selected concept in Chemistry using Concept mapping instructional strategy. But in conformity with the findings of Larbi (2011), Otor (2013), Chawla (2015) and Yakubu (2016) which shows that there is no significant difference between male and female students taught selected concept in Chemistry using Concept mapping instructional strategy on reflective thinking and academic performance.

### Conclusion

Chemistry students taught mole concept using Concept - mapping instructional strategy have higher academic performance and reflective thinking in Chemistry than those exposed to lecture method. There is no significant difference in both academic performance and reflective thinking of chemistry students based on gender when taught mole concept using concept-mapping instructional strategy. Hence, concept - mapping strategy is gender friendly among students.

### Recommendations

Based on research findings for this study, it was recommended that the use of concept - mapping strategy should be encouraged among Chemistry teachers.

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