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# Effects of Guided Discovery and Concept Mapping Strategies on Students' Achievement and Retention in Chemical Equilibrium in Nasarawa State, Nigeria

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**ABSTRACT**
The study investigated the effects of guided discovery and concept mapping instructional strategies on students' achievement and retention in Chemical equilibrium in Nasarawa State Nigeria. Two research questions guided the study and two hypotheses were tested at 0.05 level of Significance. Quasi experimental design of non-equivalent pre-test, post-test, post-post-test control group was adopted for the study. A sample of 150 Chemistry students was drawn from a population of 350 SS 2 Science Students in Science Secondary Schools in Nasarawa State. The sample was randomly assigned to two experimental groups (Guided Discovery and Concept Mapping) and one control group. The instrument used for the data collection was Chemical Equilibrium Achievement Test which has a reliability index of r = 0.75. Descriptive statistics (mean and standard deviations) were used to answer the research questions while ANCOVA and Bonferroni multiple comparison were used to test the hypotheses. The findings showed that: there was a significant difference in the mean achievement scores of students taught chemical equilibrium using guided discovery method, concept mapping strategy and lecture method in favor of guided discovery method and concept mapping strategy. ($F = 17.751$; $P = 0.000 < \alpha = 0.05$). There was a significant difference in the mean retention scores of students taught chemical equilibrium using guided discovery method, concept mapping strategy and lecture method in favour of the strategies ($F = 4.209$; $P = 0.017 < \alpha = 0.05$). Based on these findings, it was concluded that concept mapping strategy is better than guided discovery method for teaching chemical equilibrium. It was recommended that since concept mapping is superior to guided discovery method, Chemistry teachers should be well trained in how to use it for teaching this topic.
**Keywords**: Achievement, Chemical Equilibrium, Concept-Mapping, Guided Discovery, Retention.

## INTRODUCTION

Education is a natural phenomenon for imparting knowledge and skills. The major goal of any type of education is to shape and mould people in such a way that the individuals will adequately adjust well in the society. Chanchar (2004) reiterated that education is the most important and common binding activity amongst people in every society, nation and the entire world. Science education in the world today demands not only that more students should be trained as scientists, but that every citizen should have sufficient knowledge of science to be able to understand and appreciate the many facilities and opportunities of this scientific age (Fwangle & Ving, 2000).

The recent emphasis on Science, Technology and Innovations (ST&I) as a pathway to National Economic Development Stipulated that the relevance and importance of Chemistry on the promotion of ST&I activities is formidable and becoming more noticeable than ever before amongst the science subjects. Yet it is considered a great subject loaded with abstract concepts that proved difficult to learn by students' e.g chemical equilibrium, rates of reaction (Eniayeju & Tanko, 2015). The reasons for these observations are many and these include: inappropriate teaching methods, size of the curriculum at O'Level, use of unprofessional teachers to teach it (Faric, 2015). The demand for chemistry knowledge and chemistry teachers is great in Nasarawa State science secondary schools so

that students' scores in internal and external examinations will be high, thereby making the candidates' entrance into tertiary institutions easier (Eniayeju & Tanko, 2015). Chemistry is a Science subject that deals with the composition, structures and properties of matter also deals with the interactions between different types of matter and the relationships between matter and energy. Through the learning of Chemistry, it is possible to acquire relevant conceptual and procedural knowledge as well as develop understanding and appreciation of development in engineering, medicine and other related scientific and technological fields. However, to investigate the extent of students' achievement in chemical equilibrium using guided discovery method and concept mapping strategy as against conventional method is the purpose of this study.

**Table 1.1: Performance of Students in Chemistry at SSCE level (2011-2019)**

| | **Total sat** | **Credit A1-C6** | **Pass D7-E8** | **Fail F9** | **Total Fail** |
|---|---|---|---|---|---|
| Year | No of Candidates | | % of Candidates | | |
| 2011 | 560,981 | 49.96 | 27.03 | 23.01 | 50.04 |
| 2012 | 565,692 | 49.54 | 17.91 | 32.55 | 50.46 |
| 2013 | 611,687 | 44.23 | 31.51 | 24.25 | 55.76 |
| 2014 | 627,302 | 43.13 | 16.31 | 40.56 | 56.87 |
| 2015 | 653442 | 31.00 | 31.40 | 37.60 | 69.00 |
| 2016 | 745322 | 43.27 | 25.43 | 31.30 | 56.73 |
| 2017 | 752211 | 49.93 | 25.02 | 25.05 | 50.07 |
| 2018 | 761142 | 49.62 | 22.30 | 28.08 | 50.38 |
| 2019 | 762595 | 49.83 | 22.45 | 30.15 | 50.42 |

Source: WAEC Research and Statistics Unit, Annual WAEC Report 2019, Lagos

Analysis of students' achievement in chemistry in WASSCE from 2011 to 2019 showed that the achievement of students in chemistry in most cases was less than 50% credit pass was recorded which was inconsistent. From the record, it is so glaring that students may have some learning difficulties in the subject. The WAEC Chief Examiners report (2016 – 2019) identified that poor level of communication skills, inadequate practical exposure, poor quantitative skills, inability to relate concepts in Chemistry particularly in chemical equilibrium, rates of reaction to everyday life and lack of understanding of some chemistry concepts. Some other researchers have also observed this phenomenon and many reasons have been adduced for this underachievement in chemistry. Samba and Eriba (2012) opined that abstract nature of chemical equilibrium could be responsible for students under achievement in chemistry.

Chemical equilibrium is a condition in the course of a reversible chemical reaction in which no net change in the amounts of reactants and products occurs. A reversible chemical reaction is one in which the products, as soon as they are formed, react to produce the original reactants. At equilibrium, the two opposing reactions go on at equal rates, or velocities, and hence there is no net change in the amounts of substances involved. At this point the reaction may be considered to be completed; i.e., for some specified reaction condition, the maximum conversion of reactants to products has been attained. The conditions that pertain to equilibrium may be given quantitative formulation. For example, for the reversible reaction $A \leftrightharpoons B + C$, the velocity of the reaction to the right, $r_1$, is given by the mathematical expression (based on the law of mass action) $r_1 = k_1(A)$, where $k_1$ is the reaction-rate constant and the symbol in parentheses represents the concentration of $A$ (Atkins & De Paula, 2006).

For a given reaction, at some specified condition of temperature and pressure, the ratio of the amounts of products and reactants present at equilibrium, each raised to their respective powers, is a constant, designated the equilibrium constant of the reaction and represented by the symbol $K$. The value of the equilibrium constant varies with the temperature and pressure according to the principle of Le Chatelier. By methods of statistical mechanics and chemical thermodynamics, it can be shown that the equilibrium constant is related to the change in the thermodynamic quantity called the standard Gibbs free energy accompanying the reaction. The standard Gibbs free energy of the reaction, $\Delta G°$, which is the difference between the sum of the standard free energies of the products and that of the reactants, is equal to the negative natural logarithm of the equilibrium constant multiplied by the so-called gas constant $R$ and the absolute temperature $T$:

$$\Delta G^\circ = -RT \ln K.$$

The equation allows the calculation of the equilibrium constant, or the relative amounts of products and reactants present at equilibrium, from measured or derived values of standard free energies of substances (Atkins & Jones, 2008).

Guided discovery is generally defined as instruction in which learners, rather than being presented with all essential information and asked to practice using it, must discover or construct some or all of the essential information for themselves (Anaso, 2015). Guided discovery involves creativity and students' participation in a well-equipped learning environment. The guided discovery approach is a form of inquiry which involves finding unknown concepts through the use of process skills. Teachers specify learning objectives, arrange information so that clearly defines the patterns that can be used to guide learners to the objectives. The instructor initiates a stimulus and the learner reacts by engaging in active inquiry thereby discovering the appropriate response. However, the guided discovery, as a recommended approach of teaching science, is faced with some challenges in Nigeria because of the present school structure in terms of class sizes, curriculum content, grade levels and standardized tests. Guided discovery and concept mapping strategies were tried in this study to find out their effects on students' achievement and retention in chemical equilibrium.

Concept mapping which is another student centered strategy was developed by **Novak** and his associates at Cornel University (German) in 1992. Concept mapping simple means diagrammatic representation of concepts using arrows to indicate their relationship in order to represent a new knowledge structure. Novak and Godwin (2014) defines concept mapping as a schematic device for representing a set of concepts meaning embedded in a frame work of preposition. Concept mapping strategy is associated with meaningful and mastery learning. It enables students to identify the major concepts and relate them to the concepts in their existing knowledge structure (Eria, 2015; Eric, 2015). The learner therefore plays an active role in knowledge construction, which leads to meaningful learning. Concept mapping is a teaching approach where learners organize concepts and relationships between them in a hierarchical manner from more inclusive concepts to more specific and less inclusive concepts (Olorede, 2013; Oloyede, 2015; Otor, 2015). While using this teaching/ learning approach, students identify major and more inclusive concepts at the top followed by the minor and more specific concepts at the bottom. The major and more inclusive concepts are referred to as super-ordinate concepts while minor and more specific concepts are called subordinate concepts. The super-ordinate and subordinate concepts are placed in ovals and then connected using suitable linking words (Edmondson 2015, Esiodu & Soyido, 2014). This study is therefore out to find the effects of guided discovery and concept mapping instructional strategies on students' achievements and retention in secondary schools.

Achievement is the level of success or performance students attained after test has been administered to them. According to Andrew and Rebello (2013), academic achievement refers to performance on a task with measures including comprehension, quality and accuracy of answers of tests, quality and accuracy of problem-solving, frequency and quantity of desired outcome, time or rate to solution, time on task, level reasoning and critical thinking, creativity, retention and recall, and transfer of tasks. Student's achievement is an essential factor in quality education. Moreover, Deslauriers and Wieman (2011) found that the learner's experiences and situations, the quality of schools and educators, and many other factors affect academic achievement. Despite all these, academic achievement still remains an essential factor in quality education and needs urgent attention. Andriots (2018) noted that the use of inappropriate teacher centered strategies like lecture method accounts for the highest poor performance of science students. These researchers remarked that most teachers in Nigerian schools still believe that the most effective means of communicating to students (Chemistry students inclusive) is through the conventional "talk and chalk" teaching or learning strategy. According to Onyenma and Olele (2020), conventional teaching strategy involves the teacher presenting a verbal discourse mainly on a particular subject, theme or concept to the learners. This strategy of teaching entails delivering preplanned lessons to the students with little or no instructional aid that involves students‟ activity. In Nigeria, conventional teaching strategy indicates a strategy that is formal and has been in use for long. That is why this strategy is usually nicknamed 'traditional teaching strategy'. This strategy is one of the easiest to deliver and that may be why many teachers often use it without

recourse to constructive teaching strategies that can promote the acquisition of scientific understanding and achievement. Closely related to achievement is retention. This is because if knowledge is retained, then it can be recalled when needed.

Okafor (2016) stated that retention is a preservative factor of the mind. The mind acquires the materials of knowledge through sensation and perception. These acquired materials in the mind need to be preserved in form of images for knowledge to develop. When a stimulating situation occurs, retained images are revived or reproduced to make remembering possible. Hence, chemical concepts need to be presented to the learners in a way or method that touches their sub- consciousness which can trigger quick recalling of the concept being taught or learnt. According to Hornby (2011), retention is the ability to remember a thing. Retention can also be defined as the ability to keep or retain the knowledge of chemical concept learnt and to be able to recall it when required. Using concept mapping instructional strategy both high and low ability learners would be able to collaborate in terms of understanding, explaining and retaining the concepts they have learnt in chemistry class. Martin, (2013) speculated that educators could improve retention of concepts and information by explicitly creating memorable events involving visual or auditory images through the use of peer tutoring, projects, plays, simulations and other forms of active learning. Retention level drops rapidly in the first week after instruction.

Chemical equilibrium being one of the noted difficult concepts in chemistry, the two strategies guided discovery and concept mapping seemed a likely strategy to try. The problem of underachievement in Chemistry has been partly blamed on difficult Chemistry topics and inappropriate teaching strategies adopted by Chemistry teachers. These conventional methods tend to encourage rote-learning and memorization of concepts without actually exposing students to challenges that will make them to be actively engaged in the learning process. The concept of chemical equilibrium has been established as one of the Chemistry concepts that students find difficult to learn. Therefore, if achievement in Senior School Certificate Examination (SSCE) in Chemistry is to be improved, Instructional strategies like guided discovery methods and concept mapping strategies other than the conventional methods are needed to be adopted by teachers to facilitate the learning of difficult concepts.

Based on the difficulties posed by the chemical equilibrium questions to students, this research work sets out to find out whether the use of guided discovery and concept mapping instructional strategies will enhance students' achievement and retention in chemical equilibrium in Science secondary schools in Nasarawa State.

**Research Questions**

The following research questions guided the study:

1. What are the mean achievement scores of secondary school students taught chemical equilibrium using guided discovery method, concept mapping strategy and lecture method?
2. What are the mean retention scores of secondary school students taught chemical equilibrium using guided discovery method, concept mapping strategy and lecture method?

**Hypotheses**

The following hypotheses were formulated to guide the study and tested at 0.05 level of Significance.

**$H_{O1}$:** There is no significant difference in the mean achievement scores of secondary school students taught chemical equilibrium using guided discovery and concept mapping strategies and lecture method.

**$H_{O2}$:** There is no significant difference in the mean retention scores of secondary school students taught chemical equilibrium using guided discovery and concept mapping strategies and lecture method.

## METHODOLOGY

This study adopted quasi-experimental design of pre-test, post-test, post-post-test of non- equivalent control group. In this design, there were three groups which were not composed on the basis of randomization but on the basis of using intact groups that allow the research to occur in its natural setting. Quasi-experimental design also approximates the conditions of the true experiment in a setting which does not allow the control and manipulation of all relevant variables. The students in the two experimental groups and control group were taught chemical equilibrium.

The population of the study comprised all science secondary school Chemistry SS 2 students in all the co-educational government science secondary schools in Nasarawa State. This is because the topic chosen for this research work is in SS2 syllabus. The choice of co-educational science secondary school in Nasarawa state is based on the fact that gender is a variable in this study. There are eight co-educational science government secondary schools in Nasarawa state. The total population of chemistry students in the eight co-educational science secondary schools was 350.

A sample of 150 chemistry SS 2 students was drawn from a population of 350 SS 2 chemistry students in the eight co- educational science secondary school in Nasarawa state. The multi-stage sampling technique was adopted in the study. They are nine (9) special science secondary schools and eight (8) are co-educational science secondary school and only one (1) is all girls' science secondary school. Pre-test was given to all eight (8) co-educational science secondary schools and three schools that had mean scores closest to each other were randomly selected from the eight (8) co-educational science secondary schools in Nasarawa state. One school was randomly selected in each zone making three schools representing each zone. SS2 chemistry students were randomly assigned to each class in the selected school (experimental group 1, 2 and control group). The final sample for the study consists of 150 SS 2 Chemistry students from three co-educational Science Secondary schools that were located within Nasarawa state.

The instrument used for data collection for this study is Chemical Equilibrium Achievement Test (CEAT). The instrument was made up of two sections; section A and section B. Section A elicit biographical data (class and gender) while section B contains the 25-item multiple -choice questions with four options (A-D) based on the content and objectives of the topics taught during the treatment. The items/questions were selected based on 6 categories of Blooms taxonomy of cognitive domain. The categories are remembering, understanding, applying, analyzing, evaluating and creating. The test items were adapted from WAEC and NECO past questions as pre-test, post-test and post-posttest. A reshuffled version of CEAT was used for retention test. The CEAT was trial-tested using a sample of 40 SS2 Chemistry students outside the study sample. This sample is a government-owned and co-educational school which is similar to the study population and had covered the lessons on the topics chosen. The data collected were analysed using Kuder-Richardson (KR-20) and the reliability coefficient was r= 0.75.

Data collected were analysed using descriptive statistics of mean and standard deviation (SD) to answer the research questions. The research hypotheses were tested using inferential statistics comprising of ANCOVA at 0.05 levels of significance.

## RESULT OF ANALYSIS

### Research Question One

*What are the mean achievement scores of secondary school students taught chemical equilibrium using guided discovery, concept mapping strategies and lecture method?*

**Table 1: Mean Achievement Scores and Standard Deviations of Students Taught Chemical Equilibrium Using Guided Discovery and Concept Mapping and Using Lecture Method**

| Method | | Pretest | Posttest |
|---|---|---|---|
| Guided Discovery | Mean | 23.12 | 31.94 |
| | N | 50 | 50 |
| | Std. Deviation | 5.118 | 3.888 |
| Concept Mapping | Mean | 17.86 | 26.22 |
| | N | 50 | 50 |
| | Std. Deviation | 3.891 | 3.328 |
| Lecture | Mean | 17.18 | 26.40 |
| | N | 50 | 50 |
| | Std. Deviation | 3.237 | 2.499 |

Table 1 reveals the mean achievement scores of students taught equations of motion using Taught Chemical Equilibrium Using Guided Discovery and Concept Mapping and those taught using Lecture Method. The Guided Discovery group had a pre-test score of 23.12 and a post-test score of 31.94, the

Concept Mapping group had a pre-test score of 17.86 and a post-test score of 26.22 and the Lecture Method group had a pre-test score of 17.18 and a post-test of 26.40.

**Hypothesis One**

There is no significant difference in the mean achievement scores of secondary school students taught chemical equilibrium using guided discovery and concept mapping strategies and lecture method.

The result of analysis to test this hypothesis is presented in Table 2.

**Table 2**: **ANCOVA Result of Mean Achievement Scores of Students Taught Chemical Equilibrium Using Guided Discovery and Concept Mapping and Using Lecture Method**

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 1424.416[a] | 3 | 474.805 | 56.711 | .000 | .538 |
| Intercept | 2800.472 | 1 | 2800.472 | 334.492 | .000 | .696 |
| Pretest | 367.043 | 1 | 367.043 | 43.840 | .000 | .231 |
| Method | 297.234 | 2 | 148.617 | 17.751 | .000 | .196 |
| Error | 1222.357 | 146 | 8.372 | | | |
| Total | 121820.000 | 150 | | | | |
| Corrected Total | 2646.773 | 149 | | | | |

a. R Squared = .538 (Adjusted R Squared = .529)

Table 2 reveals that $F_{(2, 146)}$=17.751 was obtained with associate exact probability value of 0.001(F = 17.751; P = 0.000 <α = 0.05). Since the associated probability (0.000) is less than 0.05 set as level of significance, the null hypothesis was rejected. This indicates that there was a significant difference in the mean achievement scores of students taught chemical equilibrium using Guided Discovery and Concept Mapping and their counterparts taught with conventional method in favour of the Guided Discovery.

Based on the established difference in the achievement scores of the groups, Bonferroni Multiple Comparisons was used to determine the direction of the difference. The results of this analysis is shown in Table 3.

**Table 3: Bonferroni Multiple Comparisons Results of Mean Achievement Scores of Students Taught Chemical Equilibrium Using Guided Discovery and Concept Mapping and Using Lecture Method**

| (I) Method | (J) Method | Mean Difference (I-J) | Std. Error | Sig.[b] | 95% Confidence Interval for Difference[b] | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| Guided Discovery | Concept Mapping | 3.720* | .653 | .000 | 2.139 | 5.301 |
| | Lecture | 3.281* | .672 | .000 | 1.654 | 4.908 |
| Concept Mapping | Guided Discovery | -3.720* | .653 | .000 | -5.301 | -2.139 |
| | Lecture | -.439 | .580 | 1.000 | -1.843 | .966 |
| Lecture | Guided Discovery | -3.281* | .672 | .000 | -4.908 | -1.654 |
| | Concept Mapping | .439 | .580 | 1.000 | -.966 | 1.843 |

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Table 3 shows that there was a significant difference in the mean achievement scores of students exposed to Guided Discovery and Concept Mapping and the Lecture Method. Guided Discovery and Concept Mapping had a P value of 0.000, since 0.000 is less than 0.05 set as bench mark of significance, the hypothesis was rejected which implies a significant difference between the mean

scores of students exposed to Guided Discovery and Concept Mapping in favour of Guided Discovery. Guided Discovery and Lecture Method had a P value of 0.000, since 0.000 is less than 0.05 set as bench mark of significance, the hypothesis was rejected which implies a significant difference between the mean scores of students exposed to Guided Discovery and Lecture Method in favour of the Guided Discovery. Concept Mapping and Lecture Method had a P value of 1.000, since 1.000 is greater than 0.05 set as bench mark of significance, the hypothesis was not rejected which implies no significant difference between the mean scores of students exposed to Concept Mapping and Lecture Method.

**Research Question Two**

*What are the mean retention scores of secondary school students taught chemical equilibrium using guided discovery, concept mapping strategies and lecture method?*

**Table 4: Mean Retention Scores and Standard Deviation of Students Taught Chemical Equilibrium Using Guided Discovery and Concept Mapping and Using Lecture Method**

| Method | | Posttest | Retention |
|---|---|---|---|
| Guided Discovery | Mean | 31.94 | 27.18 |
| | N | 50 | 50 |
| | Std. Deviation | 3.888 | 4.835 |
| Concept Mapping | Mean | 26.22 | 21.76 |
| | N | 50 | 50 |
| | Std. Deviation | 3.328 | 3.815 |
| Lecture | Mean | 26.40 | 21.20 |
| | N | 50 | 50 |
| | Std. Deviation | 2.499 | 3.239 |

Table 4 reveals the mean retention scores of students taught equations of motion using Guided Discovery and Concept Mapping and Lecture Method. For the Guided Discovery group, the post-test score is 31.94 and the retention score (Post-post-test) is 27.18. For the Concept Mapping group, the post-test score is 26.22 and the retention score (Post-post-test) is 21.76. For the Lecture Method group, the post-test score is 26.40 and the retention score (Post-post-test) is 21.20.

**Hypothesis Two**

There is no significant difference in the mean retention scores of secondary school students taught chemical equilibrium using guided discovery and concept mapping strategies and lecture method

The result of analysis to test this hypothesis is presented in Table 5.

**Table 5**: **ANCOVA Result of Mean Retention Scores of Students Taught chemical equilibrium Using Guided Discovery, Concept Mapping and Lecture Method**

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 1748.228[a] | 3 | 582.743 | 49.606 | .000 | .505 |
| Intercept | 54.466 | 1 | 54.466 | 4.636 | .033 | .031 |
| Posttest | 657.388 | 1 | 657.388 | 55.961 | .000 | .277 |
| Method | 98.889 | 2 | 49.445 | 4.209 | .017 | .055 |
| Error | 1715.112 | 146 | 11.747 | | | |
| Total | 85457.000 | 150 | | | | |
| Corrected Total | 3463.340 | 149 | | | | |

a. R Squared = .505 (Adjusted R Squared = .495)

Table 5 reveals that $F_{(2, 147)} = 20.811$ was obtained with an exact associate probability value of 0.000 ($F = 4.209$; $P = 0.017 < \alpha = 0.05$). Since the associate probability (0.017) is less than 0.05 set as level of significance, the null hypothesis was rejected. This implies that there was a significant difference was found to exist in the mean retention scores of students taught equations of motion using Guided Discovery and Concept Mapping and Lecture Method.

Based on the established difference in the achievement scores of the groups, Bonferroni Multiple Comparisons was used to determine the direction of the difference. The results of this analysis is shown in Table 6.

**Table 6: Bonferroni Multiple Comparisons Results of Mean Retention Scores of Students Taught Chemical Equilibrium Using Guided Discovery and Concept Mapping and Using Lecture Method**

| (I) Method | (J) Method | Mean Difference (I-J) | Std. Error | Sig.[b] | 95% Confidence Interval for Difference[b] | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| Guided Discovery | Concept Mapping | 1.741 | .844 | .122 | -.302 | 3.785 |
| | Lecture | 2.417* | .835 | .013 | .396 | 4.439 |
| Concept Mapping | Guided Discovery | -1.741 | .844 | .122 | -3.785 | .302 |
| | Lecture | .676 | .686 | .978 | -.985 | 2.336 |
| Lecture | Guided Discovery | -2.417* | .835 | .013 | -4.439 | -.396 |
| | Concept Mapping | -.676 | .686 | .978 | -2.336 | .985 |

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Table 6 shows that there was a significant difference in the mean retention scores of students exposed to Guided Discovery and Concept Mapping and the Lecture Method. Guided Discovery and Concept Mapping had a P value of 0.122, since 0.122 is greater than 0.05 set as bench mark of significance, the hypothesis was not rejected which implies no significant difference between the mean scores of students exposed to Guided Discovery and Concept Mapping.

Guided Discovery and Lecture Method had a P value of 0.013, since 0.013 is less than 0.05 set as bench mark of significance, the hypothesis was rejected which implies a significant difference between the mean scores of students exposed to Guided Discovery and Lecture Method in favour of the Guided Discovery group.

Concept Mapping and Lecture Method had a P value of 0.978, since 0.978 is greater than 0.05 set as bench mark of significance, the hypothesis was not rejected which implies a significant difference between the mean scores of students exposed to Concept Mapping and Lecture Method

## DISCUSSION OF FINDINGS

The findings of this study revealed that, there was a significant difference in the mean achievement scores of students taught chemical equilibrium using Guided Discovery and Concept Mapping and their counterparts taught with conventional method in favour of the Guided Discovery and Concept Mapping strategy. The null hypothesis was rejected, there was a significant difference in the mean achievement scores of students taught chemical equilibrium using guided discovery method and concept mapping strategy better than lecture method. This finding agreed with those of Omiko and Akani (2015), Abdullahi and Adekunle (2015), Hreywood and John (2016), Maikudi and Akanmu (2016) and Moradeyo and Alex (2017) who ascertained that guided discovery method and concept mapping instructional strategies enhance students' achievement in chemical equilibrium better than lecture method.

Findings from this study revealed that, there was a significant difference was found to exist in the mean retention scores of students taught chemical equilibrium using Guided Discovery and Concept Mapping and Lecture Method. This finding agreed with those of Alex and Akani (2017) who investigated the relative effects of guided discovery method and that guided discovery method enhances better students' retention than lecture method and also Kerano and Wachanga (2015) investigated the effects of concept mapping strategy and that it enhances students' retention in chemical equilibrium better than the lecture method.

## CONCLUSION

The findings of this study have shown that Guided Discovery and Concept Mapping strategies are more effective than the Conventional Method. These results imply that the teaching approaches employed by Chemistry teachers in teaching might have been partly responsible for the persistent

under-achievement of students in Chemical Equilibrium since teachers use the conventional methods most of the times.

## RECOMMENDATIONS

Based on the findings, the following recommendations are made:

1. Chemistry teachers should adopt the use of guided discovery and concept mapping strategies in teaching chemical equilibrium thereby improving achievement and retention in Chemistry.
2. Guided discovery and concept mapping strategies should be included in the pre-service teacher training programs of pre-service Chemistry teachers especially in colleges of Education and in the University Faculties of Education

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