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# Enhancing Students' Achievement, Interest and Retention in Chemistry through an Integrated Teaching/Learning Approach

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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## ABSTRACT

This study concerns the effects of Concept Mapping-Guided Discovery Integrated Teaching Approach on the Learning Style and Achievement of chemistry students. The sample comprised 162 Senior Secondary School (SS 2) students drawn from two Science Schools in Nasarawa State, Nigeria which had equivalent mean scores of 9.68 and 9.49 in their pre-test. Five instruments were developed and validated while the sixth was purely adopted by the investigator for the study, Four null hypotheses were tested at $\alpha = 0.05$ level of significance. Chi Square analysis showed that there was a significant shift in students' learning style from Accommodating and Diverging to Converging and Assimilating when exposed to Concept Mapping- Guided Discovery Approach. Also t-test and ANOVA indicated that those who in experimental group achieved and retained content learnt better. Results of the Scheffe's test for multiple comparisons showed that boys in the Experimental Group performed better than girls. It is therefore concluded that the Concept Mapping-Guided Discovery Integrated Approach be used in secondary schools to successfully teach electrochemistry. It is strongly recommended that chemistry teachers should be encouraged to adopt this method for teaching difficult concepts.

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## 1. INTRODUCTION

Chemistry which is expected to be an interesting practical science subject is posing a great treat to many students nowadays, some have already developed phobia because of their consistent poor achievement on assessment or repeated failure in external examinations. Evidences have shown that most concepts in chemistry are indeed difficult to learn by most students [1]. It was lamented that most chemistry educators have lost excitement in carrying out their pedagogical roles, and also considers almost the entire concepts in the senior secondary school Chemistry syllabus as areas commonly found difficult to teach by graduate teachers [2,3] though [4] opined that there is no ideal situation that is devoid of one difficulty or the other and that difficulty is an inherent variable in any purposeful activity.

The secondary school knowledge of chemistry is often characterized by lack of coherence. Instead of having a well-structured and integrated domain-specific knowledge structures, students consider the different concepts as isolated elements of knowledge. Most students do not possess a well-founded basic framework in which newly acquired concepts can be integrated [5]. This lack of integration is suspected to be the basis of students' difficulties concerning concept formation and application of acquired knowledge in exercises and practical work [6].

In [7,8] it was reported that difficult concepts or topics in chemistry can be simplified by considering and incorporating the following for effective instruction: Assessing student's prior knowledge, diagnosing students' learning difficulties, relating new topic to common application and providing rationale for learning. Matching instructional strategies to students learning style, the use of problem solving method and development of problem solving skills, Concept mapping and integrating different teaching methods are very essential.

It was affirmed that most students learn in essentially the same environment and learning can be highly effective if the learning situation is consistent with how students learn [3]. Since everyone learns differently, understanding learning styles can help a teacher perform better by matching the teaching pattern with students learning styles for appropriate understanding of the lesson content [9]. There are different learning styles exhibited by students though the same method or approach is employed during classroom instruction. There is no right or wrong learning style and it has nothing to do with intelligence but it has to do with the way a person's brain works to learn and store information efficiently. There are many classifications of learning styles from different Scholars based on different perspectives, but Kolb's learning style was preferred for this study.

Researches have shown that students' attitude towards learning affect their performance and educators are interested in the learners' attitude because they are affective variables that are durable. It was observed that affective variables are as important as cognitive variable in influencing learning outcomes [10]. It is often believed that for any achievement in an endeavor, opportunity, ability and interest are the three essential ingredients of which interest is paramount. Interest (often measured by attitude and mostly reflected by individual' learning style) with its affective and cognitive dimension is a psychological construct that is considered to be a critical predictor of the behaviour of a student although the teacher is the fundamental agent in facilitating learning success in an educational situation [11].

Thechemistry teacher's creativity is tested as it is still believed that he needs to help his students overcome their fears, approach chemistry with confidence, develop problem solving skills, apply principles of chemistry when solving problems and equally understand that chemistry is a part of everyday life. He needs to emphasize the process of science and the language of Chemistry. He should also provide real-world application to his teaching as he helps his students to evaluate their learning [12,7].

Ausubel's learning theory [13] suggests that hierarchical structures should be used in promoting understanding and recall. Ausubel and Novak worked extensively on cognitive structuring. Novak and his co-worker have developed the idea of concept maps as an exemplary learning/teaching strategy [14]. Brunner advocated for cognitive restructuring through his learning theory of discovery. These two learning theories form the basic framework upon which this current study hung.

In this study, Concept Mapping and Guided discovery were combined to form the integrated teaching /learning approach which was investigated. Specifically, the effect of the approach on students' learning style, achievement and retention towards difficult chemical concepts was determined.

## 1.1 Research Questions

The following research questions were raised for this study:

1. What is the effect of Concept Mapping-Guided Discovery Integrated Approach on students' achievement in chemistry?
2. Do boys and girls perform equally well when taught electrochemistry using Concept Mapping-Guided Discovery Integrated Approach?
3. Which group of students retains chemical concepts better when exposed to Concept Mapping-Guided Discovery Integrated Approach and Demonstration method?
4. What is the effect of Concept Mapping-Guided Discovery Integrated Approach on students' learning style?

## 1.2 Hypotheses

The following null hypotheses were formulated and tested

$H_{0\ 1:}$ There is no significant difference in the achievement of students exposed to Concept Mapping-Guided Discovery Integrated Approach and those taught using Demonstration method.

$H_{0\ 2:}$ There is no significant difference in the performance of boys and girls exposed to Concept Mapping-Guided Discovery Integrated Approach and those taught using Demonstration method.

$H_{0\ 3:}$ There is no significant difference in the level of chemical concept retained by students exposed to Concept Mapping – Guided Discovery Integrated Approach and those taught with Demonstration method.

$H_{0\,4:}$ There is no significant shift in students' learning style from Accommodating & Diverging to Converging & Assimilating when exposed to Concept Mapping-Guided Discovery Integrated Approach.

## 2. METHODOLOGY

### 2.1 Population

All SS2 chemistry students in all the science secondary schools in Nasarawa State constituted the population for the study. There were 986 SS2 students in the entire population [15].

### 2.2 Sample

Stratified random sampling technique was employed to select a science school from each of the three educational zones in the state. Pre-test was conducted in the three selected schools in order to establish equivalence. GSSS Karu and GSSS Nasarawa- Eggon eventually participated in the study because of the equivalence of their pre-test mean scores which were 9.68 and 9.49 respectively. The t-test analyses showed that the groups were equivalent at 0.05 level of significance. The 162 sampled students were assigned to experimental and control group in each of the two schools.

### 2.3 Research Design

Pretest-Posttest Control –Group Design was employed for the study.

### 2.4 Instruments

Six instruments were used for this study; five were developed by the investigator and validated by experts while the sixth (learning scale inventory was adopted) [15]. They are namely;

### 2.5 Chemistry Achievement Pre-Test (CAPE)

This was made up of 20 multiple choice objective test items which were selected from past UTME and SSCE questions on Electrochemistry (Electrolysis, Redox reaction). The test items selected were distributed among the six intellectual levels of Bloom's taxonomy in the cognitive domain. The reliability index obtained for the achievement test using Kuder-Richardson method (KR-21) was 0.70.

### 2.6 Chemistry Achievement Post-Test

This consisted of 20 multiple choice objective test items and it was similar in content with the pretest. They were also drafted from past UTME and SSCE objective questions. The reliability index obtained for the achievement test using Kuder-Richardson method (KR-21) was 0.72. Equivalence of CATE and CATO was established through t –test and the result revealed that there is no significant difference between CAPO and CAPE at 0.05 level of significance.

## 2.7 Chemistry Achievement Retention-Test (CART)

This also consisted of 20 items structured objective test which was the same as the post test but the only difference was the serial rearrangement of the test items.

## 2.8 Lesson Plans for the Control Group (LPCG)

These comprised five lesson plans on the selected topic for the study. It was used for teaching the control group using demonstration method for five consecutive weeks. The objectives for all the lessons in the Control group were the same as those of the Experimental group.

## 2.9 Lesson Plan for the Experimental Group (LPEG)

These were sets of instructional guides designed only for the experimental group. There were five lesson guides on the selected topics for the study which was taught for five consecutive weeks. The experimental group used the integrated approach which is the combination of Concept Mapping and Guided Discovery approach (concept maps together with sets of questions outlined to be answered and some activities to be carried out at different stages of each topic) that was appropriately blended together.

## 2.10 Kolb Learning Style Inventory (KLSI)

This instrument was originally developed by Kolb in 1984. The Kolb version 3.1 [16] was adopted for this study. This instrument was used to obtain data on the learning styles of the students before and after the treatment in order to ascertain any shift in their learning styles.

KLSI 3.1 is intended for use by youth and any category of learners as it asks respondents to rank four sentence endings that correspond to the four learning modes - Concrete Experience, Reflective Observation, Abstract Conceptualization and Active Experimentation. It is based on the experiential learning theory and it is designed to help individuals identify the way they learn from experience. This instrument consisted of 36 items which were designed to detect how students learn best with regards to their feelings, views, behaviour and the learning situation.

## 3. PROCEDURE

The CAPE was first administered and used to determine the initial knowledge of the students on the selected topics and to select equivalent groups which participated in the study. The KLSI was administered to the experimental group before the treatment to determine the learning styles of each student in the group using rubric scoring. For five weeks, the Experimental Group was taught electrochemistry using Concept Mapping-Guided Discovery Approach while the Control Group was taught the same set of topics using Demonstration Method. The Post Test was conducted immediately after the teaching and was used to determine the effectiveness of the two methods of teaching but particularly the effect of the treatment on the experimental group. KLSI was repeated again to detect any shift in the students learning styles. Four weeks later, retention test (CART) which was to determine the amount of content material retained by the students after conducting the post test was administered.

## 4. RESULTS AND DISCUSSION

The result of the study is stated below; SPSS was used to obtain the data for all the statistical testing of the hypotheses.

$H_{0\,1:}$ There is no significant difference in the achievement of students exposed to Concept Mapping-Guided Discovery Integrated Approach and those taught using Demonstration Method.

Using both F and t tests respectively, Tables 2 and 3 shows that there is a significant difference at 5 % level of confidence in the achievements of students in the control and experimental group. Those taught with Concept Mapping-Guided Discovery Integrated Approach achieve more than those taught with Demonstration method

$H_{0\,2:}$ There is no significant difference in the performance of boys and girls when taught with Concept Mapping-Guided Discovery Integrated Approach and those taught with Demonstration method.

Hence there is a significant difference in the performance of boys and girls when taught with Concept Mapping-Guided Discovery Integrated Approach and those taught with Demonstration Method.

$H_{0\,3:}$ There is no significant difference in the level of chemical concepts retained by students exposed to Concept Mapping- Guided Discovery Integrated Approach and those taught with Demonstration method.

Table 5 clearly shows that the experimental group had higher mean scores and better retention rate than those in the control group.Since the calculated t-value is greater than the critical t-value, we reject the $H_{0\ 3}$. Hencethere is a significant difference in the level of retention of chemical materials by students taught using the Concept Mapping-Guided Discovery Integrated Approach and those taught with the Demonstrated Method.

From the profiles of School 1 Students' Learning Styles before and after Treatment, it is seen that there are major shifts in the learning styles of the students from Accommodating (25% before treatment to 11% after treatment) and Diverging (30% before treatment to 13 % after treatment) to Assimilating (22.5% before treatment to 55% after treatment).

From Table 6b, showing the profiles of School 2 Students' Learning Styles before and after Treatment, a similar pattern was presented that there are major positive shifts in the learning styles of the students from Accommodating (30% before treatment to 17.5% after treatment) and Diverging (27.5% before treatment to 20 % after treatment) to Assimilating (27.5% before treatment to 40% after treatment).

Using the Chi-Square test statistic for testing the hypothesis, the test statistics is given by the formula:

$$\chi^2_{calculated} = \sum_{i=1}^{n} \left\{ \frac{(O_i - E_i)^2}{E_i} \right\} =$$

where $O_i$ is the observed frequency, and $E_i$is the expected frequency corresponding to every observed frequency and is calculated as follows: $E_i = \frac{R_T \times C_T}{G_T}$ [$R_T$ , $C_T$ and $G_T$are the Row totals, Column totals and Grand totals].

$\chi^2_{calculated} = 10.26.$ for school1 and $\chi^2_{calculated} = 11.82.$ for school 2

Degree of freedom=(r-1) X (c-1) = (2-1) X (4-1) =3. Thus the critical value at $\alpha$=0.05 is $\chi^2_{3,0.05} = 7.815$.

Since the calculated values 10.26 and 11.82 are greater than the critical value 7.815 at $\alpha$=0.05 significant level, the null hypothesis is rejected. Hence, we conclude that there is a significant shift in students' learning style from Accommodating & Diverging to Converging & Assimilating when exposed to Concept Mapping- Guided Discovery Approach.

From Tables 1, 2 and 3, the results show that there was a remarkable improvement in the achievement of students taught with the Concept Mapping –Guided Discovery Integrated Approach as compared to those taught with demonstration methods. This result is consistent with the findings of [17] where they reported and established that both Guided-discovery and Concept-mapping are effective teaching methods when used independently. Since in this study, the two teaching approaches were blended, it is expected that students' achievement would improve considerably as it did.

**Table 1. Means and standard deviations of post test scores for experimental and control groups in the schools**

| School | Group | No. of students | Range of scores | Mean score | Std. deviation | Std. error |
|---|---|---|---|---|---|---|
| GSS Karu (School 1) | Experimental | 40 | 12 | 13.80 | 3.08 | 0.49 |
| | Control | 40 | 6 | 11.45 | 1.45 | 0.23 |
| GSS Nasarawa | Experimental | 40 | 7 | 14.75 | 1.81 | 0.29 |
| Eggon (School 2) | Control | 42 | 9 | 9.25 | 1.86 | 0.29 |

**Table 2. Results of ANOVA of post-test mean scores for schools 1 & 2 respectively**

| | Sum of squares | Df | Mean square | F-cal | F-crit | Decision |
|---|---|---|---|---|---|---|
| **School 1** | | | | | | |
| Between groups | 24.660 | 9 | 2.740 | 1.436 | 1.350 | Significant |
| Within groups | 57.240 | 30 | 1.908 | | | |
| Total | 81.900 | 39 | | | | |
| **School 2** | | | | | | |
| Between groups | 22.294 | 9 | 2.787 | 1.461 | 1.350 | Significant |
| Within groups | 57.240 | 30 | 1.908 | | | |
| Total | 81.900 | 39 | | | | |

*Decision: Since $F_{calculated}$ is greater than the $F_{critical}$, we reject $H_0$*

**Table 3. Result of t-test analyses of post–test mean scores for schools 1& 2 respectively**

| School 1 groups | No of students | Mean score | Standard deviation | t-cal | t-crit = $t_{0.05,78}$ | Decision |
|---|---|---|---|---|---|---|
| Experimental | 40 | 13.80 | 3.08 | 4.68 | 1.67 | Significant |
| Control | 40 | 11.45 | 1.45 | | | |
| **School 2 groups** | **No of students** | **Mean score** | **Standard deviation** | **t-cal** | **t-crit = $t_{0.05,80}$** | **Decision** |
| Experimental | 40 | 14.75 | 1.81 | 13.57 | 1.67 | Significant |
| Control | 42 | 9.25 | 1.86 | | | |

*Since $t_{calculated}$ is greater than the $t_{-crit,}$ we reject $H_{01}$, Since$t_{calculated}$ is greater than the $t_{-crit,}$ we reject $H_{01}$*

It was discovered from Table 4 that a considerable gap still exist between the achievement of boys and girls when taught under the same condition particularly when taught using Concept Mapping – Guided Discovery Integrated Approach with the boys performing better than their female counterparts. This result supports the outcomes of earlier studies by [17,18], that boys perform better in Sciences than girls.

**Table 4. Results of scheffe's test on post test mean Scores for school 1&2 respectively**

| School1 groups | Gender | N | Mean score | Range of score | Standard deviation | $S_{calculated}$ - value | $S_{critical}$ - value |
|---|---|---|---|---|---|---|---|
| Experimental | Male | 21 | $\bar{x}_1 = 15.14$ | 10 | 3.23 | 31.76 | 5.70 |
| | Female | 19 | $\bar{x}_2 = 12.32$ | 13 | 2.14 | | |
| Control | Male | 27 | $\bar{x}_3 = 11.82$ | 13 | 1.44 | | |
| | Female | 13 | $\bar{x}_4 = 10.69$ | 11 | 1.18 | | |
| **School 2 groups** | **Gender** | **N** | **Mean score** | **Range of score** | **Standard deviation** | $S_{calculated}$ - value | $S_{critical}$ - value |
| Experimental | Male | 24 | $\bar{x}_1 = 15.04$ | 9 | 1.78 | 49.70 | 5.70 |
| | Female | 16 | = 14.31 | 7 | 1.82 | | |
| Control | Male | 22 | $\bar{x}_3 = 8.86$ | 10 | 2.14 | | |
| | Female | 20 | $\bar{x}_4 = 9.90$ | 9 | 1.41 | | |

*Since $S_{calculated}$ is greater than the $S_{critical}$, we reject $H_{02}$, Since $S_{calculated}$ is greater than the $S_{critical}$, we reject $H_{02}$*

**Table 5. Results of the t-test analyses for content retention by the groups in schools 1**

| Group | No of students | Range of scores | Mean score | Standard deviation | t-cal | t-crit = $t_{0.05,78}$ | Decision |
|---|---|---|---|---|---|---|---|
| Experimental | 40 | 9 | 14.87 | 1.92 | 4.68 | 1.67 | Significant |
| Control | 40 | 12 | 11.45 | 1.45 | | | |

*Since $t_{calculated}$ is greater than the $t_{-crit,}$ we reject $H_{0\,3}$*

Students exposed to the Integrated Approach retain the knowledge of chemical concepts gained during teaching better than those taught using Demonstration method as shown in Table 6. This is also in conformity with the observation made by [19], as he stated that new teaching strategies often enhance learning, students' productivity and retention.

**Tables 6 a & b profiles of students' learning styles before and after treatment in school 1&2 respectively**

| Implementation period | Learning styles | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Accommodating | | Diverging | | Converging | | Assimilating | |
| | N | % | N | % | N | % | N | % |
| Before treatment | 10 | 25 | 12 | 30 | 09 | 22.5 | 09 | 22.5 |
| After treatment | 04 | 11 | 05 | 13 | 08 | 21 | 21 | 55 |
| **Implementation period** | **Learning styles** | | | | | | | |
| | **Accommodating** | | **Diverging** | | **Converging** | | **Assimilating** | |
| | **N** | **%** | **N** | **%** | **N** | **%** | **N** | **%** |
| Before treatment | 12 | 30.0 | 11 | 27.5 | 06 | 15 | 11 | 27.5 |
| After treatment | 07 | 17.5 | 08 | 20 | 09 | 22.5 | 16 | 40 |

There is also a meaningful shift in the learning styles of students as shown from Table 6 and Table 7 from accommodating and Diverging to Assimilating and Converging. Assimilating is a combination of reflective observation and abstract conceptualization. This involves learning by creating and applying conceptual models, attracting to new challenges and experiences and using inductive reasoning effectively. This is appropriate for science subjects especially for Chemistry which is practical oriented. In the Kolb's Learning Style Inventory [16], Converging implies a combination of Abstract Conceptualization and Active Experimentation which involves doing and thinking, solving practical problems and the likes, experimenting and simulation.

**Table 7. Contingency table for chi - square test of students' learning styles in school 1&2 before and after treatment**

| Learning style | School 1 | | | School 2 | | |
|---|---|---|---|---|---|---|
| | Before treatment | After treatment | Total | Before treatment | After treatment | Total |
| Accommodating | $O_1$=10 | $O_2$=04 | | $O_1$=12 | $O_2$=07 | |
| | $E_1$=7.18 | $E_2$=6.82 | 14 | $E_1$=8.5 | $E_2$=8.5 | 19 |
| Diverging | $O_3$=12 | $O_4$=05 | | $O_3$=11 | $O_4$=08 | |
| | $E_3$=8.72 | $E_4$=8.28 | 17 | $E_3$=9.5 | $E_4$=9.5 | 19 |
| Converging | $O_5$=09 | $O_6$=08 | 17 | $O_5$=06 | $O_6$=09 | 15 |
| | $E_5$=8.72 | $E_6$=8.28 | | $E_5$=7.5 | $E_6$=7.5 | |
| Assimilating | $O_7$=09 | $O_8$=21 | 30 | $O_7$=11 | $O_8$=16 | 27 |
| | $E_7$=15.39 | $E_8$=14.62 | | $E_7$=14.5 | $E_8$=14.5 | |
| Total | 40 | 38 | 78 | 40 | 40 | 80 |

The students in the experimental group in the two schools showed by their comments (feedback) on their lesson guides after each instruction that the integrated approach is a welcome and appropriate method for learning and have produced a positive change in their attitude towards learning chemistry. Though some of the students earlier conceived Electrochemistry as a difficult concept, but later realized through the new learning approach

that it is not so. This result agreed with the observation of [10], that students' attitude affect their performances and learning outcome in the sciences.

## 5. CONCLUSION

The study implicates that Concept Mapping – Guided Discovery Integrated Approach is an effective teaching method for learning difficult chemical concept/topicse specially Electrochemistry. Chemistry content is better retained when this approach is employed because it adopts problem based learning (an integral part of guided discovery method), that enhances cognitive restructuring and linkage of ideas to existing knowledge structure [5]. It is therefore recommended that Chemistry educators get acquainted with and adopt this novel approach of teaching/learning chemistry.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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