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# Effect of Concept Mapping Teaching Approach on Students' Academic Performance in Chemistry in Senior Secondary Schools

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## ABSTRACTS

This study investigated the effect of the concept mapping teaching approach on students' performance in Chemistry in senior secondary schools regarding a periodic table concept. W analyzed 11,094 chemistry students from eleven public senior secondary schools in Katsina. Two schools and 128 Senior Secondary chemistry students formed the sample for the study. Three research questions with hypotheses were raised and formulated respectively to guide the study. The study was a non-equivalent pre-test and post-test control group involving one experimental group and one control group. The chemistry Performance Test was used for data collection. The study revealed that there is no significant difference in the mean performance scores of students taught a periodic table concept using concept mapping and those taught the same concept before the treatment. There is a significant difference in the performance of the students taught a periodic table concept using concept mapping and those taught the same concept using a conventional teaching method after the treatment. Also, there is no significant difference in the mean performance score that exists between male and female chemistry students.

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## 1. INTRODUCTION

Chemistry is an important science subject that occupies a prominent place in the school curriculum. It is one of the science subjects taught at senior secondary and tertiary levels of education in Nigeria. It is defined as that branch of science that deals with the study of the composition, properties, and activities of organic and inorganic substances and various elementary forms of matter (see *http://antoine.frostburg.edu/chem*).

A concept map is a graphical tool for organizing and representing knowledge developed as a schematic approach to the representation of the relationships among concepts. A concept map consists of concepts placed in nodes connected by links with propositions representing and identifying the relationships between the nodes. Concept maps are organized hierarchically from the most general to more detailed and focused ideas (sub-concepts). Concept mapping may be used as an active learning strategy when a teacher employs it in the process of teaching and learning. Its approaches to classroom situations are practical, hence the learners have opportunities to be highly involved in the process of teaching and learning.

The use of concept mapping in the teaching of Chemistry in secondary school would be of great benefit as it would make the learners fully participate in the classroom activities, therefore, making the process interesting and practical. Chemistry plays a significant role in the economic development of a nation and this underscores the reasons for emphasizing its promotion as the means of achieving technological development in many countries. Striving for development in science and technology becomes imperative as it serves as a driving wheel for the economic empowerment of many countries. Therefore, for a country to be economically viable, it must strengthen its science and technology programs in content as well as in teaching and learning at the secondary school level.

Among all the science subjects, Chemistry is vital for preparing scientists and technologists both at middle and upper manpower levels. Chemistry is one of the basic sciences which are essentially the pre-requisites for many sciences and technology-related courses such as medicine, engineering, pharmacy, and computer science, among others, in tertiary institutions. Hence, the need for effective Chemistry education in Nigeria appears very crucial and therefore, demands considerable attention. For instance, Chemical technologists and Technical workers are needed in all those chemistry-related fields mentioned above. In the higher manpower requirement, experts are needed in chemical engineering.

These fields cannot be effectively studied without Chemistry as it serves as a prerequisite to them. This implies that Chemistry is an important science subject needed for higher education in virtually all science-related professions. Yet, despite the importance of chemistry to the unfolding world, the performance of Nigerian students in the subject at the secondary school remains an abysmal failure. It is disappointing to note that students' performance in Chemistry at internal and external examinations has remained considerably poor despite the relative its importance. These consistent poor performances in chemistry external examinations among Senior Secondary School students have given a lot of concern to educators, curriculum planners, and students themselves.

Academic performance refers to the ability to demonstrate the accomplishment of academic goals for which learning experiences were designed. Performance is an important academic factor that has been identified to be influenced by teaching methods. Teaching method influences students' performance in chemistry, while the students are likely to achieve well in a discipline, they have an interest. However, the performance of students in chemistry may also be influenced by gender.

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Gender is a socio-culturally ascribed attribute that differentiates feminine from masculine. Gender is used to describe certain characteristics of men and women which are naturally, culturally, and socially determined while those that are biologically determined are regarded as sex. Gender is one of the factors interacting with performance in Chemistry and other sciences. However, the influence of gender on students' academic performance is still conflicting as there exist varied contradicting among researchers.

Jahun and Mmoh (2011), and Mari (2019), reported that male students have a higher performance in Chemistry than females. Some of the factors identified to have accounted for the observed differences in the performance of male and female students in Chemistry are sex-role stereotyping, masculine image of science, and the female socialization process.

Contrary to the above finding, gender influenced performance in the favour of females. While on the other hand, no significant difference in the performance of students due to gender. Instead, they opined that the performance of both males and females can be affected by teaching and learning styles and therefore advocated the need to adapt teaching approaches that would enhance the academic performance of both males and females in the school system. Poor and ineffective instructional strategies have also been reported as a major factor responsible for the recorded poor performance of students in Chemistry (Akinsola and Igwe, 2009).

These researchers also revealed that the traditional lecture method which does not promote cognitive and meta-cognitive development is the predominantly used teaching method (Akinsola & Igwe, 2017). The traditional lecture method is a method of teaching in which the teacher delivers the lesson to students with little or no active participation of students. It is a teacher-centered approach involving largely a one-way form of communication from the teacher to the students. Resultantly, it is termed the didactic approach because most of the talking is done by the teacher while the students remain passive listeners. Unfortunately, this method of instruction is predominantly used by teachers in teaching most school subjects.

Most times, science teaching remains a telling instruction rather than doing; in both primary and secondary schools due to the teachers' adoption of the lecture method of instruction. The vestige of the traditional lecture system of teaching still prevails in most schools. The researcher further maintained that when the traditional lecture method of teaching is employed, students' ability to grasp relevant concepts is made more difficult than when they are exposed to activity-based methods. The conventional teaching method does not involve the active participation of the learners in the learning process. Secondly, it does not offer the learners the opportunity of using their cognitive structures in the process of learning.

Furthermore, it encourages rote learning or memorization due to a lack of understanding or poor comprehension of facts which are often presented in abstraction. Research evidence, showed that many difficulties in learning and understanding Chemistry appear to be caused by how Chemistry instruction is passed on to the students. The desire to enhance students' academic performance in these areas demands a shift from the perception of what the teacher does to what the learner does in the teaching and learning process through more effective, student-centered, activity and problem-based strategies. Learners should be seen as active participants in the process of knowledge acquisition and not as passive recipients of information from the teacher.

Akinsola and Igwe (2017) opined that teachers should adopt instructional methods that can bring about attitudinal change and acquisition of skills by learners to enable them to address societal challenges. They postulate that teaching methods like activity, inquiry, and

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discovery which are affective and psychomotor stimulating could be used. They further suggested the use of the following methods in teaching chemistry: inquiry method, role play, dramatization, field trips, simulation–game, problem-solving, concept mapping, use of resource persons, and analogies. Nevertheless, it is difficult to point to one teaching strategy that could lead to the realization of all learning outcomes about the natural world. The researcher, however, suggested some Meta-cognitive strategies like concept mapping which help students to organize concepts into meaningful, as opposed to, loosely connected entities.

Secondly, concept mapping is one of the strategies described by UNESCO/UNEP as being of high potential value to the teacher and quite essential to the teaching of chemistry. Their perceived effectiveness may have informed their inclusion in the secondary education curriculum among methods that should be used by teachers. Unfortunately, also maintained that secondary school Chemistry teachers hardly ever use these methods because they do not have adequate knowledge of what concept mapping is and how to use it.

Chemistry has been accorded a very high recognition as one of the important science subjects. Over the years, results of studies conducted by different scholars and researchers in the field of Chemistry have shown that students continued to perform poorly in SSCE Chemistry. A lot of reasons have been adduced to explain the situation. These include teacher-centered methods of teaching, non-availability of resources and materials, overloaded curriculum, poor classroom management, and lack of adequate scientific equipment in the secondary schools' laboratories.

Idris and Rajuddin (2012), and Alaka and Obadara (2013) reported that the prevailing teaching method in many Nigerian secondary schools is the lecture method. This method according to them does not allow active students' participation in Chemistry lessons rather students memorize and regurgitate facts and concepts without acquiring a basic understanding of the concepts. Also, they do not have the understanding of the scientific basis for the relevance of the concepts that are needed for achieving mastery of the knowledge of the curriculum content of Chemistry. Detailed analysis of SSS Chemistry students' performance in Nigeria indicated a persistent failure in Chemistry. For instance, of the total number of 171,232 candidates who registered and sat for WAEC in 2012, Only 40,582 students representing 23.7% passed Chemistry at credit level.

In 2013, there was a decrease in the number of passes as only 20.7% scored credit and above. Even though the percentage of the pass at the credit level rose to 36% in 2014, the performance decreased to 33.5 in 2015 and 25.3 in 2016 respectively. It was also reported that the performance of the candidates in Chemistry for the year 2017 was below average and was worse compared to the following year.

This situation is so discouraging realizing the fact that Chemistry is one of the core science subjects and the National University Commission (NUC) prescribes passing at credit level before admitting any students into any science-based courses at the university level. By implication, many students who want to study Medicine, Pharmacy, Engineering, and other related science disciplines lose their chances due to poor performance in chemistry. There is, therefore, a need to search for a more effective instructional strategy that is likely to improve and remedy the students' academic performance in SSS Chemistry. As such, this research intends to find out the effect of concept mapping on the performance of students in chemistry among senior secondary school students in Katsina Metropolis.

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The objectives of the study are:

(i) Examine the difference in the mean performance scores of students taught a periodic table concept in Chemistry using concept mapping and those taught the same concept using the conventional teaching method before the treatment.
(ii) Determine the difference in the mean performance scores of students taught a periodic table concept in Chemistry using concept mapping and those taught the same concept using a conventional teaching method after the treatment
(iii) Find out the difference in the mean performance scores of male and female students taught the concept of periodic table concept in Chemistry using concept mapping

The following research questions were formulated for this study;

1. What is the difference in the mean performance scores of students taught a periodic table concept in Chemistry using concept mapping and those taught the same concept using a conventional teaching method before the treatment?
2. What is the difference in the mean performance scores of students taught a periodic table concept in Chemistry using concept mapping and those taught the same concept using a conventional teaching method after the treatment?
3. What is the difference in the mean performance scores of male and female students taught a periodic table concept in Chemistry using concept mapping?

The following hypotheses were tested at a 0.05 level of significance.

(i) **$HO_1$:** There is no significant difference in the mean performance scores of students taught a periodic table concept in Chemistry using concept mapping and those taught the same concept using a conventional teaching method before the treatment.
(ii) **$HO_2$:** There is no significant difference in the mean performance scores of students taught a periodic table concept in Chemistry using concept mapping and those taught the same concept using a conventional teaching method after the treatment.
(iii) **$HO_3$:** There is no significant difference in the mean performance scores of male and female students taught the concept of the periodic table in Chemistry using concept mapping

## 2. METHODS

A quasi-experimental design was adopted for the study. Specifically, the pre-test, post-test, and non-equivalent control group design was employed for the study and the population of this study consists of all SS II students who offer chemistry in all the public senior secondary schools in Katsina Metropolis with a total number of eleven thousand and ninety-four (11,094). The sample size of this study consists of 128 SS II Chemistry students drawn from two Government co-educational senior secondary schools in Katsina metropolis. The purposive sampling technique was used to select two schools that have at least two streams of SS II chemistry classes from the total number of eleven schools in the metropolis. Finally, there was the random assignment of classes from each school to experimental and control groups.

Chemistry Performance Test (CPT) was adapted from West African Senior School Certificate Examination (WASSCE) past questions (2007-2020) to serve as a pre-test to ascertain equivalence of ability of subject and as a post-test to determine the effect of the treatment on students' performance in chemistry based on periodic table concept. The instrument was validated by an expert. The Kuder-Richardson 21 formula was used and a reliability index of 0.72 was obtained. Three research questions and three research hypotheses were generated for the study. The research questions were answered using mean and standard deviation. Hypotheses were tested using a t-test.

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## 3. RESULTS AND DISCUSSION

**3.1. Research Question 1:** What is the difference in the mean performance scores of students taught a periodic table concept in Chemistry using concept mapping and those taught the same concept using a conventional teaching method before the treatment?

**Table 1** shows that the experimental group recorded a mean of 10.33 and a standard deviation of 2.01 while the control group recorded a mean of 10.51 and a standard deviation of 1.67. The mean difference of 0.19 which is approximately 0.00 shows that the students taught a periodic table concept in Chemistry using concept mapping and those taught the same concept using a conventional teaching method has no difference in their performance before the treatment. The standard deviation of both shows that the individual performance score is closer to each other, but the individual academic performance score in the control group is a little closer to each other.

**Table 1.** Mean and standard deviation of experimental and control groups.

| Groups | N | Mean | SD | M.D |
|---|---|---|---|---|
| Experimental | 64 | 10.33 | 2.01 | |
| | | | | 0.19 |
| Control | 64 | 10.51 | 1.67 | |

**3.2. Research Question 2:** What is the difference in the mean performance scores of students taught a periodic table concept in Chemistry using concept mapping and those taught the same concept using a conventional teaching method after the treatment?

**Table 2** shows that the experimental group recorded a mean of 15.55 and a standard deviation of 2.20 while the control group recorded a mean of 11.75 and a standard deviation of 1.98. The mean difference of 3.80 shows that the students who taught a periodic table concept in Chemistry using concept mapping performed better than those who taught the same concept using a conventional teaching method after the treatment. The standard deviation of both shows that the individual performance score is closer to each other.

**Table 2.** Mean and standard deviation of experimental and control groups.

| Groups | N | Mean | Std. Deviation | Mean Difference |
|---|---|---|---|---|
| Experimental | 64 | 15.55 | 2.20 | |
| | | | | 3.80 |
| Control | 64 | 11.75 | 1.98 | |

**3.3. Research Question 3:** What is the difference in the mean performance scores of male and female students taught a periodic table concept in Chemistry using concept mapping?

**Table 3** shows that the male students recorded a mean of 15.71 and a standard deviation of 2.03 while the female students recorded a mean of 15.45 and a standard deviation of 2.32. The mean difference of 0.26 shows that both male and female students taught a periodic table concept in Chemistry using concept mapping performed equally. The standard deviation of both male and female students shows that the individual performance score is closer to each.

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**Table 3.** Mean and standard deviation of male and female students in experimental group.

| Gender | N | Mean | SD | M.D |
|---|---|---|---|---|
| Male | 24 | 15.71 | 2.03 | |
| | | | | 0.26 |
| Female | 40 | 15.45 | 2.32 | |

**3.4. Hypothesis $HO_1$:** There is no significant difference in the mean performance scores of students taught a periodic table concept in Chemistry using concept mapping and those taught the same concept using a conventional teaching method before the treatment?

**Table 4** shows that the mean difference that exists between experimental and control groups is 0.19. The calculated, t-value is 0.574 with a p-value of 0.567, while the alpha value is 0.05. The result from the analysis shows that the p-value is greater than the alpha value. Therefore, the null hypothesis is retained. This means that there is no significant difference in the performance of the students taught a periodic table concept in Chemistry using concept mapping and those taught the same concept using a conventional teaching method before the treatment.

**Table 4.** T-test analysis of difference in the mean performance of experimental and control groups before the treatment.

| Group | N | Mean | S. D | M.D | D.F | T– value | P-value | Remark |
|---|---|---|---|---|---|---|---|---|
| Experimental | 64 | 10.33 | 2.01 | | | | | |
| | | | | 0.19 | 126 | 0.574 | 0.567 | Accepted |
| Control | 64 | 10.51 | 1.67 | | | | | |

$\alpha \leq 0.05$

**3.5. Hypothesis $HO_2$:** There is no significant difference in the mean performance scores of students taught a periodic table concept in Chemistry using concept mapping and those taught the same concept using a conventional teaching method after the treatment?

**Table 5** shows that the mean difference that exists between the experimental and control groups is 3.80 in favor of the experimental group. The calculated, t-value is 10.24 with a p-value of 0.000, while the alpha value is 0.05. The result from the analysis shows that the p-value is less than the alpha value. Therefore, the null hypothesis is not retained. This means that there is a significant difference in the performance of the students taught a periodic table concept in Chemistry using concept mapping and those taught the same concept using a conventional teaching method after the treatment.

**Table 5.** t-test analysis of the difference in the mean performance of experimental and control groups after the treatment.

| Group | N | Mean | S.D | M.D | D.F | T– value | P-value | Remark |
|---|---|---|---|---|---|---|---|---|
| Experimental | 64 | 15.55 | 2.20 | | | | | |
| | | | | 3.80 | 126 | 10.24 | 0.000 | Rejected |
| Control | 64 | 11.75 | 1.98 | | | | | |

$\alpha \leq 0.05$

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**3.6. Hypothesis $HO_3$:** There is no significant difference in the mean performance scores of male and female students taught a periodic table concept in Chemistry using concept mapping.

**Table 6** shows that the mean difference that exists between male and female students taught using the concept of the periodic table using concept mapping is 0.26 which is approximately 0. The calculated t-value is 0.451 with a p-value of 0.653, while the alpha value is 0.05. The result from the analysis shows that the p-value is greater than the alpha value. Therefore, the null hypothesis is retained. This means that there is no significant difference in the mean performance score of male and female students taught a periodic table concept in Chemistry using concept mapping.

**Table 6.** t-test analysis of difference in mean performance score between male and female students taught a periodic table concept in Chemistry using concept mapping.

| Group | N | Mean | S.D | M.D | DF | T - value | P-value | Remark |
|---|---|---|---|---|---|---|---|---|
| Male | 24 | 15.71 | 2.03 | 0.26 | 62 | 0.451 | 0.653 | Accepted |
| Female | 40 | 15.45 | 2.32 | | | | | |

$\alpha \leq 0.05$

### 3.7. Discussion

Firstly, there is no significant difference in the performance of the students taught a periodic table concept in Chemistry using concept mapping and those taught using a conventional teaching method before the treatment. The findings of this study also revealed that there was a significant difference in the performance of the students taught a periodic table concept in Chemistry using concept mapping and those taught using a conventional teaching method after the treatment.

This is in line with Ezeudu (2011) who revealed that concept mapping had a significant effect on students' overall performance in selected Chemistry concepts. It was also discovered that concept mapping was more effective than the conventional teaching method in terms of students' performance in Chemistry concepts. It was also in line with Ezeugo and Agwagah (2000) who revealed that students taught with concept mapping performed significantly better than students taught with the traditional teaching method.

The study of the findings revealed that there is no significant difference in the mean performance score of male and female students taught a periodic table concept in Chemistry using concept mapping among Senior Secondary School students in Katsina metropolis. This is not in support with Ezeugo and Agwagah (2000) who revealed that the male students taught with concept mapping performed significantly better than their female counterparts taught with concept mapping.

## 4. CONCLUSION

Based on the findings of this study, it was concluded that there is no significant difference in the mean performance scores of students taught a periodic table concept using concept mapping and those taught the same concept using the conventional teaching method before the treatment while there is a significant difference in the performance of the students taught a periodic table concept using concept mapping and those taught the same concept using a conventional teaching method after the treatment, also there is no significant difference on the mean performance score that exists between male and female chemistry students taught

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a periodic table concept using concept mapping. It is therefore recommended that chemistry teachers should incorporate concept mapping as one of the techniques used in teaching chemistry in the classroom to facilitate the learning of scientific concepts, laws, and theories.

Based on the findings of this study, the following recommendations are considered appropriate:

(i) Chemistry teachers should incorporate concept mapping as one of the techniques used in teaching chemistry in the classroom to facilitate the learning of scientific concepts, laws, and theories.

(ii) There should be in-service training for science teachers through intensive workshops and seminars on modern teaching techniques such as concept mapping. This will help to enhance their competence, especially in the choice and use of the various innovative teaching strategies.

(iii) Curriculum developers should include the teaching of concept mapping techniques in the chemistry education curriculum of teacher education institutions.

(iv) Government should encourage science teaching and learning by providing enabling environment for the stimulation and sustenance of the learner's attitude toward science. Availability of adequate classrooms, laboratories, equipment, and facilities for the teaching of science will enable the teacher to effectively use the concept mapping technique which has been found to enhance students' attitudes in the learning of chemistry more than the lecture method.

## 5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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