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Effectiveness of Concept Mapping in Chemistry Education among Secondary School Students in Ilorin, Kwara State of Nigeria

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Abstract— *This study investigates the effectiveness of concept mapping in chemistry education among secondary school students in Ilorin, Kwara State of Nigeria. It also examines the challenges of using concept mapping as a teaching method. The quasi-experimental method was employed and a total of 53 participants in the experimental group and 31 in the control group were selected using multistage sampling techniques. The research tool used contains a problem-solving achievement test in radioactivity and also items on the challenges to concept mapping. Results revealed that concept mapping is an effective learning strategy that can significantly improve students' comprehension and retention of knowledge in Chemistry. However, to maximize its effectiveness, teachers need to provide proper guidance and support to students, create a conducive learning environment, and ensure that there is an adequate feedback mechanism in place. Additionally, adequate training and support are required to use concept mapping effectively as a teaching tool.*

Keywords— *Chemistry education, concept mapping, students, students' achievement.*

I. INTRODUCTION

The scope of science education seems to be growing with growing number of research in the field of education so as to have a better understanding on how individuals learn and how teaching practices can be optimized to facilitate learning. One of the innovative methods developed to enhance teaching and learning is the concept mapping. Concept mapping is a visual learning tool that helps students organize and connect complex information by creating a visual representation of concepts and their relationships (Chikendu, Obikezie, & Abumchukwu, 2021). The use of concept mapping has been gaining popularity in recent years due to its effectiveness in enhancing learning outcomes in various subjects, including chemistry. According to Mohamad, Affandi, and Awang (2019), the use of concept mapping in teaching chemistry could be very beneficial to students in understanding and retention of the subject matter.

Chemistry is a fundamental science course that is essential for students who wish to pursue further studies in fields such as medicine, pharmacy, engineering, and computer engineering in tertiary institutions. Additionally, chemistry is an integral part of our daily lives, as humans have always interacted with chemical products and technology in various forms. These products include cosmetics, drugs, detergents, soaps, fertilizers, insecticides, and electricity, among many others. Eze (2017) opined that chemistry can be defined as the scientific study of matter, its properties, the reasons why substances combine or separate to form other substances, and how they interact with energy. Understanding chemistry is crucial because it helps us to comprehend the world around us and to appreciate the role that chemical processes play in shaping our daily experiences. By studying chemistry, students can acquire a deeper understanding of chemical reactions, chemical equilibrium, chemical thermodynamics, and chemical kinetics, among other essential topics.

The teaching of chemistry in secondary schools is crucial because it helps to equip students with the knowledge and skills needed to pursue further studies in the sciences and to develop a better understanding of the world around them. Effective teaching is so crucial to learning since it is product of teaching as knowledge, attitude and skill acquisition are much dependent on the teacher's effective teaching (Eguabor, 2005). Effectiveness of a teacher relies on so many factors most especially on the skills of the teaching and the teaching methods.

Concept mapping is therefore, one of the activity-based instructional strategies. Activity-based strategies are known to enhance acquisition of science attitudes (Akporehwe & Onwioduokit, 2010). This is because the meaningful learning that concept mapping promotes proceed more easily when new concept or meaning of concept are subsumed under broader, more inclusive concepts. Concept mapping can be used to teach various topics in chemistry, including organic chemistry, inorganic chemistry, physical chemistry, and analytical chemistry. For instance, inorganic chemistry involves the study of the properties and behavior of inorganic compounds. The subject is complex and requires students to understand the relationship between different elements and their properties (Markow & Lonning, 2008). Using concept mapping could help students visualize the connections between different elements and their properties, making it easier for them to understand and remember the information.

Despite the importance of Chemistry in science education, secondary school students in Ilorin, Kwara State, Nigeria still find it challenging to comprehend the abstract concepts and theories of chemistry due to the nature of the subject; some Chemistry topics are even more difficult to comprehend by students some of which include radioactivity, chemical kinetics, and topics on inorganic chemistry etc. To improve students' understanding and enhance their academic performance in

chemistry, various teaching strategies, including concept mapping, have been introduced. Despite the growing interest in the use of concept mapping as a teaching strategy, little is known about its effectiveness in improving chemistry education among secondary school students in Ilorin, Kwara State of Nigeria. Furthermore, there is limited research on the effectiveness of the use of concept mapping as opposed to traditional teaching methods. The study therefore investigates the effectiveness of concept mapping in Chemistry education among secondary school students in Ilorin, Kwara State. Specifically, this study:

i. investigates the effectiveness of concept mapping in chemistry education among secondary school students in Ilorin, Kwara State of Nigeria.
ii. examines the challenges of using concept mapping in chemistry education among secondary school students in Ilorin, Kwara State of Nigeria.

II. Empirical Studies

Empirical evidences have revealed that concept mapping remains a vital tool that enhances teaching of Chemistry in secondary schools particularly in comprehension of the topics and retention of the knowledge. Okereke and Ezechukwu (2016) conducted a study to investigate the effectiveness of concept mapping on the academic performance of 136 senior secondary school students from two randomly selected schools in Anambra State, Nigeria. The study results indicated that the group that received concept mapping instruction performed significantly better than the control group in a chemistry achievement test. Another study conducted by Okebukola and Jegede (2014) focused on examining the effect of computer-aided concept mapping on the performance of senior secondary school students in chemistry in Ogun State, Nigeria. The study involved 120 students who were randomly divided into two groups: an experimental group that received computer-aided concept mapping instruction and a control group that received traditional instruction. The results showed that the experimental group had significantly higher mean scores in the post-test than the control group. Furthermore, it was revealed that concept mapping enhances understanding of complex concepts, facilitates critical thinking and fosters creativity.

Similarly, in line with the aforementioned, Ajewole and Ogunniyi (2018) using 100 senior secondary school students, explored the impact of concept mapping on secondary school students' achievement in chemistry in Ogun State, Nigeria. It was shown that the experimental group that received concept mapping instruction had higher mean scores. A related study also provided further information to expose that concept mapping can promote active learning and collaboration among students (Adeyemo & Adeyemi, 2016). In addition, Ajaja (2011) determined the effects of concept mapping as a study skill on students' achievement in biology. The findings of this study indicated a significant and consistent improvement in biology achievement as the period of experience with the use of the method increased and also, students who use concept mapping as a study skill retained biological knowledge longer than those who use other methods.

In addition to having good learning experience, studies have also shown that concept mapping can help students have a better understanding of topics that seem ordinarily difficult to comprehend. For instance, in radioactivity which is a topic under nuclear chemistry has also been a major challenge to secondary school students. Similarly organic chemistry has also been giving students hard time to comprehend while using the traditional teaching methods. Ajewole and Ogunniyi (2018) also, examined the effect of computer-aided concept mapping on the performance of 120 senior secondary school students in Ogun State, Nigeria. It was shown that group that received the treatment score significantly higher than the control group.

Studies have identified some major challenges of using concept maps as learning strategy in teaching science related subjects. Duarte et al., (2017) found in their studies that students can generally have low level of assimilation using the concept maps methods especially when proper guidance is not provided. This is also similar to the findings of Hwang et al., (2011) whose study focused more on online concept mapping approach. According to their findings, the major challenges to the effectiveness of concept mapping are in the area of guidance of students and inadequacies that exist in the feedback mechanism. The is also the need for scaffolding and support for students who are new to the concept mapping process as well as proper training and support teachers in using this method (Buhmann & Kingsbury, 2015)

III. Methodology

The study was a quasi- experimental design. It was pre-test - post-test non-equivalent control group design. This was because the researcher cannot sample and assign the subjects to experimental groups at random. The quasi-experimental study involved two independent variables i.e., gender, teaching-learning strategy, having two levels of each variable. All senior secondary school (SSS II) students offering chemistry in Ilorin South Educational Zone constitute the population of the study. A total of 53 participants (experiment) and 31 (control group) were selected using the multistage sample technique. The problem-solving achievement test in radioactivity (PSATR) test was used in collecting data for the study. The PSATR was a 10-item multiple-choice objective test items (having one key and three distracters) as pre-test to ascertain equivalence of ability of subject and as post-test to determine the effect of the treatment on ability to solve numerical problems in chemistry based on radioactivity. The tool also contained items to collect data on the challenges of using concept mapping as a teaching method for Chemistry Education. Data collected from the respondents were analyzed using descriptive and inferential statistics.

IV. Results

TABLE 1: Mean Achievement Pre-Test Score of Students Exposed to Concept Mapping Strategy and those Exposed to Traditional Teaching Methods

Group	N	Mean	SD
Experiment	53	7.72	1.54
Control	31	7.32	1.39

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TABLE 2: ANCOVA Showing the Difference Between Pre-Test Achievement Scores of Students Exposed to Concept Mapping Strategy and Those Exposed to the Traditional Teaching Method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	61.741[a]	3	20.580	22.774	.000
Intercept	6161.540	1	6161.540	6822.634	.000
Pre-test	4.915	1	4.915	.544	.473
Error	72.295	80	.904		
Total	7101.00	84			
Corrected Total	134.036	83			

a. R Squared = .646 (Adjusted R Squared = .440)

Table 1 shows that the mean achievement score of the experimental group in the pre-test is 7.72 (SD=1.542), which is higher than the mean of the control group of 7.32(SD=1.393). Furthermore, result presented in Table 2 on the hypothesis the difference between the post-test achievement scores of students exposed to the concept mapping strategy and those exposed to the traditional teaching method revealed that the F-value of 0.544 is obtained with a p-value of 0.413 computed at 0.05 alpha level. Since p-value (0.413) is greater than alpha level (0.05), it is therefore evident that there is no significant difference between the pre-test achievement score of those exposed to concept mapping strategy and those exposed to the traditional teaching method.

TABLE 3: Mean Achievement Post-Test Score of Students Exposed to Concept Mapping Strategy and Those Exposed to Traditional Teaching Methods

Group	N	Mean	SD
Experiment	53	9.96	1.20
Control	31	8.31	1.54

TABLE 4: ANCOVA Showing the Difference Between Post-Test Achievement Scores of Students Exposed to Concept Mapping Strategy and Those Exposed to the Traditional Teaching Method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	61.741[a]	3	20.580	22.774	.000
Intercept	6161.540	1	6161.540	6822.634	.000
Post-Test	58.091	1	58.091	64.282	.000
Error	72.295	80	.904		
Total	7101.00	84			
Corrected Total	134.036	83			

a. R Squared = .646 (Adjusted R Squared = .440)

For the post-test score of students exposed to concept mapping strategy it is evident that the mean achievement score of the experimental group in the post-test is 9.96(SD=1.20), which is higher than the mean of the control group of 8.31 (SD=1.54). Furthermore, the tested hypothesis on the difference between the Post-Test achievement score of students exposed to the concept mapping strategy and those exposed to the traditional teaching method revealed that F-value of 64.282 is obtained with a p-value of 0.00 computed at 0.05 alpha level. Since p-value (0.00) is less than alpha level (0.05), it is therefore evident that there is a significant difference between the Post-Test achievement score of those exposed to concept mapping strategy and those exposed to the traditional teaching method.

TABLE 5: Challenges of Using Concept Mapping in Chemistry Education among Secondary School Students

Challenges	Agree (%)	Disagree (%)	Mean Score	SD
Learning environment	52.5	48.5	1.53	0.18
Academic background	31.6	68.4	1.32	0.33
Teachers skills/qualification	60.5	37.5	1.59	0.25
No proper guidance	66.3	33.7	1.66	0.13
Poor feedback mechanism	58.5	41.5	1.56	0.27
Insufficient instructional time	52.5	48.5	1.53	0.21

Source: Survey, 2021

In Table 5, it is evident that the main challenges of using concept mapping in Chemistry education among secondary school students is lack of guidance on the part of the teachers (66.3%) and mean score of 1.66 (SD=0.13), teachers skills (60.5%) and mean score of 1.59 (SD=0.25), poor feedback mechanism (58.5%) and mean score of 1.56(SD=0.27), learning environment (52.5%) with mean score of 1.53 (SD=0.18) and insufficient instructional time (52.5%) with mean score of 1.53 (SD=0.21). Academic background of the students does not seem to be a major challenge to the use of concept mapping in teaching and learning Chemistry as a subject among secondary school students.

V. DISCUSSION

The result of the study shows that concept mapping is an effective strategy in teaching Chemistry to secondary school students, as evidenced by the significant difference in the post-test achievement scores of the experimental group (exposed to concept mapping) and the control group (exposed to traditional teaching method). This finding is aligns with the results of several empirical studies conducted in Nigeria that have investigated the effectiveness of concept mapping in improving students' academic performance. It corroborates the findings of Okebukola and Jegede (2014) who that the experimental group that received computer-aided concept mapping instruction had significantly higher mean scores in the post-test than the control group that received traditional instruction. This is also the case for the study of Okereke and Ezechukwu (2016). These findings suggest that concept mapping can enhance students' comprehension and retention of knowledge in Chemistry. Furthermore, in tandem with the result, the findings of Ajewole and Ogunniyi (2018) and Adeyemo and Adeyemi (2016) revealed that concept mapping can promote active learning and collaboration among students, which can lead to deeper understanding of the subject matter. This is because concept mapping requires students to actively engage with the material, organize their thoughts and ideas, and make connections between different concepts. This process can help students to identify their misconceptions and clarify their understanding of complex concepts.

On the challenges of using concept mapping, findings from this study revealed that some of the major challenges include lack of guidance and support, poor feedback mechanism, learning environment, and insufficient instructional time. This finding corroborates with that of Taiwo and Osuolae (2019) findings revealed that the lack of technical know-how/skills of

the teachers on the use of concept mapping tools and inadequate instructional time. To further back the findings, Sadi and Erdemir (2015) found that students faced difficulties in selecting the main concepts to be included in the concept maps, making meaningful connections between concepts, and organizing the information in a logical and coherent manner while Onyema and Ozoemena (2013) revealed that students experience difficulties in constructing and interpreting concept maps due to inadequate prior knowledge and insufficient vocabulary.

VI. Conclusion and Recommendations

This study examined the effectiveness of concept mapping in chemistry education among secondary school students in Ilorin. The study also exposed the challenges to the effectiveness of concept mapping as a teaching method. From the findings, the study concludes that concept mapping is an effective learning strategy that can significantly improve students' comprehension and retention of knowledge in Chemistry. However, to maximize its effectiveness, teachers need to provide proper guidance and support to students, create a conducive learning environment, and ensure that there is an adequate feedback mechanism in place. Furthermore, teachers need to receive adequate training and support in using concept mapping effectively as a teaching tool. The training should include the technical skills needed to use concept mapping tools and strategies for providing effective guidance and feedback to students.

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