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Relative Effectiveness of Computer Simulation Instructional Package and Four Mode Application Technique in Teaching Difficult Chemistry Concepts in Secondary Schools in Nigeria

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Abstract The study identified the concept-Electrolysis in Ordinary Level West African School Certificate (WASC) chemistry syllabus as a topic that was not usually well taught by Chemistry Teachers due to either lack of competence or inappropriate pedagogical skills by the Chemistry Teachers. Hence the study examines the relative effectiveness of Computer Simulation Instructional Package (CSI), Four Mode Application Technique (4MAT) and Lecture Method (LM) in improving students' performance in chemistry. The study adopted a pretest post-test experimental design with lecture method as the control group. The sample consisted of 180 participants selected from three Senior Secondary School II (SSS II) Chemistry Students in Akure North Local Government Area of Ondo State. The sample was classified into two experimental groups (CSI =60), (4MAT = 60) and a control group (LM = 60). A 15 item instrument tagged Electrolysis Chemistry Achievement Test (ECAT) was developed by the researcher and ascertained for reliability ($r = 0.78$, $p<0.05$). The study was guided by two hypotheses. Data collected were analysed using ANOVA. The results showed that there was a significant difference in the effectiveness of CSI and 4MAT on students' performance in chemistry $f_{(2,177)} = 7.121$. Furthermore, CSI was found to be more effective (X = 11.88) than 4MAT (X =11.03) . The study concluded that CSI is an effective method in teaching electrolysis in secondary schools in Nigeria.

Keywords: *4MAT, computer simulation, relative effectiveness, performance, electrolysis*

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1. Introduction

Science education is a creative and intellectual learning unifying concepts, theories and laws of man natural environment and its application, controlling the environment for the benefit of man. The current goal of science education in Nigeria according to Coulter [1] include among others; the identification of the fundamental aspects of science, the development of science attitudes such as accuracy, honesty, open mindedness, objectivity, critical thinking and drawing conclusion. It has been observed over the years, that these goals of science education have not been achieved to an appreciable level either due to inappropriate teaching techniques or incompetence in terms of mastery of the subject matter by the science teacher.

The major goal of science education is to develop scientifically literate individuals that have the competence for national thoughts and actions. The objectives of science education in Nigeria according to Fatokun [2] include the need to prepare students to observe and explore the environment, explain simple natural phenomena, develop scientific attitudes including curiosity, apply the skills and knowledge gained through science to solve everyday problems in the environment, develop self-confidence and self – reliance through problem solving activities in science.

The importance of science is anchored on chemistry as one of the basic science subjects for scientific development. Chemistry is one of the basic requirements for some professional courses such as medicine, pharmacy, engineering and technology courses. Chemistry is seen as the most important area of study because the discovery of atom and elements that form organs and cells in human body are due to the study of chemistry.

Chemistry is presumed to be the fulcrum upon which all other sciences and technology are attached. It serves as a prerequisite for almost science and technology programmes in the tertiary level of education [3].

It has been recognized that most students have difficulties with aspects of Chemistry that involve

qualitative and quantitative consideration, that is why Omoniyi (2017), [4] observed that students have difficulties in understanding mole concepts, a quantitative aspects involving calculations. The abstract nature of chemistry makes it relatively difficult when compared with some other non-science concepts. Reports of several studies revealed that most concepts in chemistry makes are indeed difficult to learn by most students [2]. Okebukola [5] itemized concepts in chemistry syllabus that both Graduate and students teachers found difficult to teach. These concepts include chemical equilibrium, nuclear chemistry, rate of chemical reactions, redox reactions and electrolysis.

Based on these findings, the researcher has chosen one of the identified difficult concepts, electrolysis, and found out the relative effectiveness of two innovative and student centered pedagogy; Computer Simulation Instruction and Four Mode Application Technique in teaching electrolysis in secondary schools in Ondo State, Nigeria.

Many researchers had carried out various researches on how to bring about teaching and effective learning of some difficult concepts in chemistry in secondary schools. The desire to improve science through more effective instructional strategies and recognition of the prominent role of information and communication technology (ICT) in advancing knowledge and skills necessary for effective functioning in the modern world calls for an urgent need to integrate ICT into education in Nigeria [6]. In this 21st century, the growth of the technology and computer oriented education systems guide educators to explore new teaching method as a remedial in handling some difficult concepts in chemistry. To achieve the objectives of the National Policy on Education, there is the need for appropriate innovations, activity based and student centered pedagogy for effective teaching and learning of some difficult concepts in chemistry such as Electrolysis as identified by Okebukola [5].

Computer can be used for instructional purpose in different modes such as tutorials modes, drill and practice, simulation modes, play methods among others. Computers are employed in modern teaching techniques to assist teachers overcome the challenge of students' poor performance in some concepts in chemistry.

Computer Simulation is a package that presents information in a step by step format with the participation of the user in order to progress in it use [7]. Simulation can be applied in teaching process because it provides real life setting of abstract concepts and encourages students to become active participant in the learning process. It can serve as a technique for enhancing learning and increase students' interest and awareness in the topic being taught. Simulation provide opportunities for learners to explore environments that mirror real world situations. Simulations also provide innovative ways to use technology. New computer technologies allow for a variety of strategies to design learning environments that are realistic, authentic, engaging and fun making while learning [8]. Simulations provide students with an opportunity to practice problem – based- learning through a specific task, issue or problem. An experience or real-life situation is imitated. Computer simulation could substitute and imitate original or a display of man-real behavior where all learners are to manipulate screen "objects" for exploring underlying concepts. It is a representation of the behavior or characteristics of a system through the use of another outlet especially a computer programmes designed for the purpose [1,9]. Simulation strategy is one of the activity-based strategies of teaching science.

In this study therefore, Computer Simulation Instructional Package (CSIP) was used to teach the concept-electrolysis, which is considered to be a difficult topic in ordinary level West African School Certificate Chemistry Syllabus in Nigeria. The effectiveness of CSIP was compared with four Mode Application Technique (4MAT) learning cycle model in teaching the topic-Electrolysis.

Mode Application Technique (4MAT) learning cycle model is an instructional model that could be used to take care of the differences in the way students learn and enhance their imaginative, analytical and manipulative skills by developing their potentials in the area of abstract experimentation and conceptualization.

What is 4MAT learning Cycle Model?

The 4MAT learning cycle model is a framework for creating a dynamic style of teaching by accurately visualizing the learning process that each learner goes through. 4MAT provides a common framework for understanding the way in which individuals and groups go through the process of interpreting, assimilating, acting and integrating knowledge.

The 4MAT LC model is based on the four different styles of learning developed by David Kolb. Each of the categories from the final model is based on a question that reflects what the learner is looking for in new knowledge. In addition to being used in the classroom, the model is also suitable for use in the organizational fields, for example, for presentation. It helps teachers to make their lessons more interesting because, learning by doing, encourages and stimulates a higher level of students' involvement and understanding of the concept taught.

Bernice McCarthy developed and published the 4MAT learning Cycle Model in 1980. She researched how children learned and created her theory by combining existing theories with practical knowledge through experimentation and abstract conceptualization. The theories that she used for this were Kolb's Model of learning styles and the concept of the two brain halves that process information in a different way. In summary, there are four learning styles outlined in the 4MAT model in relation to the dynamic that arise through interaction between the observation mode and information processing mode.

Observing and Processing Information

The 4MAT learning cycle model explains how people learn in terms of observing and processing information.

The learning styles in the 4MAT Learning Cycle Model

4MAT learning cycle model has four types of learners with different learning styles which could be used for effective teaching and learning of chemistry by unlocking students imaginative, analytical and abstract conceptualization potential.

The four types of learners are;

1) The imaginative learner

Imaginative learners make connections quickly for themselves and others. They desire personal meaning and

involvement in knowing the why of a problem. That is, why should I learn this?

2) Analytical learner

The analytical type of learner likes to listen, think about information and come up with ideas. Analytical learner is interested in acquiring facts and enjoy doing independent research. The analytical learner favorite question: What should I learn?

3) Common Sense Learner

The common sense learner is interested in carrying out experiments, build, design and create ideas. The common sense learner favorite question is: how should I learn?

4) Dynamic learner

The dynamic learner is interested in researching ideas to make adjustment. They learn through self-discovery. Dynamic learners' favourite question is: what if I learn?

The learning styles in the 4MAT learning cycle model

Although every person prefers a particular learning styles, according to Bernice McCarthy's 4MAT model, every learner goes through the entire process mentioned above. There is a difference in the learning styles of the four types of learners.

The 8- Step learning process

The 4MAT learning cycle model has four phases in a learning cycle, attached to a separate style of learning. Every learning style is determined by the way the left and right halves of the brain function, which means every quadrant has a left and right mode. The left half prefers structure and order, language and numbers and works to analyse information. The right half includes visualization, images, searches for patterns and creates metaphors. A high dynamic between the left and the right half is crucial for higher learning and thinking, and stimulates. The 8- step sequential model that is made up of four quadrants are used as instructional package to teach the students in experimental group I.

Many researchers such as Omoniyi [4], have carried out various researches on how to bring about effective teaching and learning in chemistry in secondary schools in Nigeria.

The desire to improve science teaching through more effective instructional strategies and recognition of the prominent role of information and communication technology (ICT) in advancing knowledge and skills necessary for effective functioning in the 21st century, calls for an urgent need to integrate ICT into Education Curriculum in Nigerian [6] to enhance effective performance of chemistry students in the 21st century, there is the need for technology and computer oriented education systems that will guide educators to explore innovative teaching methods in teaching chemistry for the objectives of the National Policy on Education to be met. Computer can be used for instructional purposes in different modes such as tutorial modes, drill and practice, simulation modes, play methods among others. Computers are employed in modern teaching techniques to assist teachers overcome the challenge of students' poor performance in chemistry.

1.1. The Concept of Computer Simulation

A computer simulation is a teaching tool used to provide students with a realistic experience. It can serve as a technique for enhancing learning and increase a student's interest and awareness in the topic being discussed. Simulations provide opportunities for learners to explore environments that mirror real-world situations or complex ideas. Simulations also provide innovative ways to use technology. New computer technologies allow for a variety of strategies to design learning environments that are realistic, authentic and engaging [8]. Computer simulations are techniques which aim to provide the student with a largely simplified reproduction of part of a real or imaginary world. They are considered "one of the most effective ways to promote deep conceptual understanding of the real world" [8]. Computer simulations are computer-generated versions of real-world objects.

Educational simulations are generally classified into four types namely; physical, interactive, procedural, situations [10].

In this study, physical simulation will be employed as a computer simulation instruction in teaching electrolysis.

In physical simulation, a learner manipulates variables in an open – ended environment and observes the results. An example is the observation of molecules under influence of temperature and pressure. The learner is able to manipulate extraneous variables in order to see effects. Chemistry, hence the method should be used sparingly and carefully.

1.2. Conventional Method of Teaching

This is a process of verbally delivering a pre-planned body of knowledge to a class in a one way teacher to student style. The conventional method, according to Ibe and Nwosu [11] is a method of teaching in which the teacher delivers the lesson to students with little or no active participation of the students.

Guisti, [12] referred to conventional teaching method as teacher-centered approach to learning in the sense that the teacher and those up in the educational hierarchy are considered as the possession of knowledge to be transferred to the students, and as such decides how the knowledge transfer takes place. The conventional teaching method stresses more on the transmission of knowledge in a manner that emphasizes memorization, hence, they have been characterized by some educators [11] as a poor method of teaching chemistry/ Biology and other science subjects. The conventional teaching methods involve unidirectional flow of information/knowledge from teacher to students and do not encourage process skill acquisition needed for proper understanding of science (Chemistry) principles, concepts and facts. The unidirectional flow of information in the traditional teaching method makes students passive and unable to construct meaningful knowledge in the teaching and learning.

2. Theoretical Framework

The theoretical framework for both the 4MAT learning cycle model and computer simulation package (CSIP) is anchored on constructivist theory. Although, several other theories form a basis for the use of Computer Simulation.

These theories have relevant implication for teaching, and learning science. Specifically, CSIP is also anchored on the philosophical idea of Skinner. Computer Assisted instruction was based on the theory of stimulus response with reinforcement or operant conditioning.

Constructivism is not a teaching theory but rather a theory of learning which argued that human beings generate knowledge and meaning from interaction between their experience and ideas. Thus, to the constructivists, learning is simply the experience gained by learners' interaction with the environment. Hence, the constructivist like the cognitive theorists see learners as active creator of knowledge. The theory of constructivism states that students need to construct their own meaning based on a learning experience [13]. This learning theory lays emphasis on active role of learning in the process of constructing and reconstructing their own knowledge based on their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences.

Constructivism as a pedagogy signifies the idea of intellectual independence. According to this pedagogy, the role of the teacher is to help the learners develop their own formations [14]. The essential core of constructivism is that learners actively construct their own knowledge and meaning from their experiences. Constructivism, the leading learning theory of the 1990's supports computer – based instruction.

Therefore, activity theory is the theoretical framework on which this study is based through the use of computer simulations by the teacher to create an environment that will help the learners to reach their level of potential development which Vygotsky's [13] work suggested can be reached with the help of a teacher or more capable peer. In view of this, Vygotsky sees teaching and learning as what cannot be judged by what the child can do when working alone but rather how far ahead the learners can go when offered some assistance by a mere experienced person (teacher).

To guide the study, two hypotheses were generated namely

1) There is no significant difference in the pre-test scores of students on the concept of electrolysis
2) There is no significant difference between the academic performance of students exposed to Computer Simulation Instruction, 4MAT learning cycle mode and traditional teaching approaches.

3. Methods

The study adopted a pre-test, post-test control group design. The population for the study comprised all students in Senior Secondary School II in public secondary schools in Ondo State, Nigeria. The sample for the study consisted of 180 SSS II chemistry students from the three randomly selected secondary schools in Akure North Local Government Area of Ondo State. The three classes were randomly assigned to treatment and control groups. The period of administration of the treatment was five weeks. The topic chosen is Electrolysis. A topic considered to be difficult to teach by chemistry teachers and also difficult to understand by chemistry students.

Other sub topics taught under Electrolysis are:

1. Definition of Electrolysis/ laws of electrolysis and electrolytic cells
2. Electrolytes, electrodes
3. Mechanism of electrolysis- Redox reactions at the cathode / Anode

4MAT Strategy

Instructional package

QUADRANT 1: CONCRETE EXPERIENCE

STEP 1: CREATE / CONNECT

TEACHER'S ACTIVITIES

Teacher will arouse students interest by showing them ethanol inside the beaker and asked the students to smell it and write out what they perceived the liquid was.

STEP 2: EXAMINE REFLECT

STUDENTS 'ACTIVITIES

Here, students showed their experiences with others in the classroom. This step is critical to applying constructivists learning theory in a classroom where students identified the materials given to them, and the reason for studying it.

QUADRANTS 2: REFLECTIVE OBSERVATION

TEACHER'S ACTIVITIES

Step 3: students were asked to integrate their observation into concepts.

Teacher defines electrolytic cell- as the assembly of two electrodes in an electrolyte, and is used for the electrolysis of a substance (compound/ chemical solution). Teacher defines electrolysis, and state laws of Electrolysis. Electrolytic cells are explained / drawn with reference to Electrodes Anode/ Cathodes.

Step 4- Students' Activities

Students develop theories and concepts

- Reactions that take place at electrodes – Anode / cathode reactions and equations

Quadrant 3- Abstract conceptualization

Step 5- practice and using information

Teacher's Activities

Teachers state some chemical reactions that take place at the electrodes (Cathode and anode).

Students Activities

Students were asked to give the products formed at the electrodes- for example: Electrolysis of copper II textraoxosulphate (VI) solution

1. Oxidation occur at the anode (+ve electrode , anode is the +ve electrode; it attracts –ve electrons to itself)

$CuS0_4$ ionises to CU^{2+} and $S0_4^{2-}$

At the anode where oxidation takes place Anode reaction (oxidation)

$S0_4^{2-}$ $S04^{2-} + 2^{e-}$

2. Reduction takes place at the cathode (-ve electrode)

Cathode reaction (reduction)

$CU^{2+} + 2^{e-}$ $Cu_{(s)}$

Step 6. The learners complete the equation by writing the products formed. Students will also balance the equations through individual conceptualization

Quadrant 4 – Active Experimentation

Step 7

The students move beyond simple practice, and use the information in a creative way by drawing the electrolytic cell.

Teachers Reaction

Teacher guides students to demonstrate the experiment and write out their observation.

Students Activities

Students identified the type of reactions that took place and write out their observation.

Step 8

Group assignments were given to student for presentation in the next lesson

Questions

1. Distinguish between a conductor and an electrolyte
2. State laws of electrolysis
3. Give equations on Redox reactions

Students Activities

Students present the solution to the assignments in the next lesson.

Instructional Package for Computer Simulation

Guidelines for the computer simulation group (Experimental Group II)

The teacher coordinates the experimental group II for three/four weeks after which the post test was administered.

Step I: The teacher introduces the lesson and the strategy the instruction would follow

Step 2: The teacher instructs the students to insert the Video CD into the sets of computers for the use of each student (one student to one computer). The teacher instructs the student to click on "enter electro" after which she instructs them to listen to the guidelines for the virtual electro and click on 'continue.

Step 3: The teacher instructs the students to go to the selection point (home icon) on the virtual electro and click on the lesson of the day.

Step 4: The teacher instructs the students to follow the instruction being given in the virtual electro and were asked to painstakingly follow the instruction.

Step 5: The students observed the reaction in the electrolytic cell and report in their notebook

Step 6: The students give answers to the questions given to them by their teacher.

4. Data Collection and Analysis

The pretest was administered on the students in the three schools separately in the first week. This was followed by assigning the schools into groups. Experimental group I students were exposed to Electrolysis using 4MAT learning cycle approach. Experimental group II was the computer simulation group. The third group was taught using the conventional lecture method. The actual teaching took four weeks after which the pot-test was administered. At the post treatment stage which was the last week of the experiment, ECAT was administered to both the experimental and control groups as post – test. Data collected were analysed using the mean, t-test and One-way Analysis of Variance (ANOVA).

4.1. Results

Table 1 to Table 4 present the result.

Table 1. Mean, Standard deviation of pre-test scores

Group (s)	N	X	Std. Dev
4MAT	60	4.58	1.77
Computer simulation	60	4.50	1.79
Lecture method	60	4.55	1.79

Table 2. ANOVA summary table of pre-test scores

Source of Variation	SS	df	Ms		
Between Group	0.211	2	0.106		
Within Group	-562.433	177	3.178	0.033	0.967
Total	562.644	179			

Sig ($p<0.05$).

Table 3. Mean and standard deviation of post-test scores of students in the experimental and control group

Group	n	X	Std. Dev
4MAT	60	11.88	2.45
Computer simulation	60	11.03	2.05
Lecture method	60	10.67	1.89

Table 4. ANOVA Summary Table of post-test scores

Source of Variation	SS	df	Ms		
Between Group	63.344	2	32.67	7.121	0.001
Within Group	812.65	177	4.59		
Total	877.39	179			

Sig ($p<0.05$).

5. Discussion

The results showed that Computer Simulation Instruction was an effective method in chemistry teaching in secondary schools which was reflected in the students mean score (X = 11.88) after treatment while the mean score of students who were exposed to ECAT using 4MAT was relatively lower (X = 11.53) considering the lecture method teaching strategy, students' performance in the Electrolysis Chemistry Achievement Ten (ECAT) was very low (X =10.07) because students in this group were not exposed to activity- based student centered method of teaching which could enhance their academic performance. Furthermore, the ANOVA result $f_{(2,177)} = 7.12$, $p<0.01$ shows that there was significant difference in the performance of students exposed to the three teaching approaches CSI was the most effective (X = 11.88) compared with 4MAT (X = 11.53) and lecture method (X =10.07) in improving students performance. CSI is most effective due to its ability to captivate and hold the attention of students with what s learnt. The instructional package is activity-based and student centered.

Also, it gives students the opportunity to repeat a slide if they missed any information. The results of the analysis of this study agreed with the finding of Omoniyi and

Ominowa [15], Oloruntegbe and Odutuyi [10] who reported that computer instructional media enhance students' performance in chemistry in secondary schools in Nigeria. It also enhances communication between learners and teachers.

This finding is also in tandem with Akingbemisilu [7] who reported that pre-degree students taught Biology through simulation games had a better achievement than those thought through the conventional method. Also, the results is in line with [10] who reported that simulated instructional approach fostered higher achievement in Biology than the conventional approach.

6. Conclusion and Recommendation

The study concluded that Computer Simulation Instruction Approach is most effective in enhancing students' performance than the 4MAT and conventional lecture methods. This means that the inability of teacher to teach electrolysis effectively and of students to perform well in some concepts in chemistry could be due to lack of facilities and resources that could be used for effective teaching and learning through the application of computer simulation instructional package. Thus, it can be recommended that CSI could be used to enhance students' performance in chemistry especially Electrolysis.

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