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Computer simulation and video media instructional packages in improving learning outcomes of Chemistry students in Ife Central Local Government Area

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Abstract

The study examined computer simulation and video-media in improving students' performance in Chemistry and compared students' attitude towards Chemistry using the two packages. It also examined the effectiveness of the two packages in enhancing students' retention of Chemistry concepts. This was with a view to finding out which of the two packages is better in enhancing students' performance in Chemistry. The non-equivalent pretest—posttest control group research design was employed for the study. The population for the study comprised all Chemistry students in senior secondary schools in Osun State. Students in senior secondary class two (SSII) in their intact classes from three schools in Ife Central Local Government Area of the State formed the sample of the study. The three schools were randomly assigned to three groups; experimental group A using Computer Simulated Instructional Package (CSIP), experimental group B using Video Media Instructional Package (VMIP), and group C using the conventional teaching method. The instruments used for data collection were Chemistry Achievement Test (CAT) and Chemistry Attitudinal Questionnaire (CAQ). Data collected were analyzed using mean, ANOVA and ANCOVA statistics. The results revealed that there existed a significant difference in the effectiveness of computer simulation and video media instructional packages in improving students' performance in Chemistry ($F=16.170$, $p<0.05$). This was further supported by the analysis of the post test scores of the respondents as those exposed to the computer simulation package had the highest post test score of 13.63 while conventional method had the lowest post test score of 9.46. The results also showed that there was no significant difference in the students' attitude towards Chemistry using the two packages ($F=0.14$, $p>0.05$). Furthermore, the results showed that there existed a significant difference in the effectiveness of the two packages in enhancing students' retention of Chemistry Concepts ($F=20.152$, $p<0.05$). Further analysis revealed a mean retention score of 14.79 for video media package, 15.54 for computer simulation package and 11.10 for the conventional method. This showed that those exposed to Computer simulation package had the highest average retention sore. The study concluded that computer simulation package is a more effective instructional package than video-media in improving students'

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performance as well as retention of concepts taught. In terms of students' attitude towards Chemistry, the two packages examined in the study suggest no effect and if such exists, is likely to be negligible.

Keywords Computer simulation, Video media, Instructions packages, Improving learning outcomes, Chemistry students

Introduction

The technological development of any nation lies in the study of science, especially chemistry. As observed by Udofie and Udo (2006), the role of Chemistry in national development is acknowledged in the whole world. The significance of chemistry in all fields of science and technology has made chemistry imperative to be included in the curriculum of senior secondary school to be offered by science students. The Nigerian secondary school Chemistry curriculum has the following objectives:

i. Facilitate a transition in the use of scientific concepts and techniques acquired in Integrated Science with Chemistry;
ii. Provide the students with basic knowledge in chemical concepts and principles through efficient selection of content and sequencing;
iii. Show Chemistry in its inter-relationship with other subjects;
iv. Show Chemistry and its link with industry, everyday life, benefits and hazards; and
v. Provide a course which is complete for students not proceeding to higher education while it is at the same time, a reasonably adequate foundation for post-secondary Chemistry courses, (Federal Republic of Nigeria (FRN), 2014a, 2014b).

With the importance of chemistry, efforts of stakeholders and provisions made by the Federal Government of Nigeria for effective teaching and learning of chemistry, it seems the objectives of its teaching and learning as stated in the Nigerian secondary school chemistry curriculum is yet to be achieved, owing to persistent low performance of students from data obtained from West African Examinations Council (WAEC) as show below (Table 1):

Table 1 Trends of performance of Chemistry students in West African Senior School Certificate Examination May/June 2011–2019

Year	Total entry	Credit pass (A_1–C_6)	% Pass
2011	565,692	280,280	49.45
2013	639,296	462,517	72.34
2014	636,296	397,649	62.49
2015	680,357	412,323	60.60
2016	706,873	408,122	57.74
2017	704,494	441,576	62.68
2018	728,998	451,614	61.98
2019	748,250	418,998	55.99

Source West African Examination Council, Nigeria (2020)

A major educational objective in Nigeria is self-reliance and for this philosophy to be realizable, appropriate methods must be employed in the teaching of Chemistry. Chemistry is one of the science subjects which have been taught using diverse methods. For instance Gupta and Parvesh (2017) used IT- Enabled instructional package to determine the achievement of students in relation to gender in Science, while Bamidele and Oloyede (2013) used Hierarchical, Flowchart and Spider Concept Mapping Strategies in teaching Chemistry. Udoh (2012) opined that the use of simulation and appropriate technology which is learner-centered can be used to generate curiosity in students and can also be used to solve other learning related problems associated with conventional teaching methods in the classroom setting. Despite the diverse strategies employed in teaching the subject, there exists inconsistency in the performance of the students.

The reasons for poor performance in Chemistry as identified by researchers over the years include: poor instructional strategies (Bamidele et al., 2013); abstract nature of science concepts (Njoku & Eze-odurukwe, 2015); lack of qualified teachers (Okoro, 2011); poor infrastructure and inadequate laboratory facilities (Owoeye & Yara, 2011) and curriculum implementation (Omoniyi & Akinsete, 2022). The appraisal of candidates' achievement in the West African Senior School Certificate Examination (WASSCE) among WAEC member countries by Bello and Oke (2011) reveals that in Nigeria, candidates' performance at the credit level was consistently the highest for the period under review (2006–2011) in Chemistry. They also identified some areas of weaknesses of the candidates which were reported as contributing to students' poor performance. The areas identified include; Poor understanding of general principles and concepts, heat, energy changes, rates of chemical reactions, reversibility of reactions, and chemical equilibrium. The non-use of appropriate learner-centered mode of instruction devoid of the use of appropriate information technology tools in teaching may have been responsible for inconsistency in the performance of students in the subject. Hence, there is need to ensure that the instruction being designed both meets the identified need for instruction and is effective in achieving the intended learning outcome. Therefore, non-use or inappropriate use of technology in the classroom instructions is summarily robbing the students

the opportunity of maximizing gains in learning in the classrooms.

Furthermore, it is becoming increasingly important to expose students to technology, to prepare them for life in the real world. And this is one of the reasons sciences holds an important position in the curriculum of Nigerian educational system. Not only will students likely use technology in their careers, employing technology in the classroom can also offer new, creative and engaging ways of teaching. Learning can be enhanced with images, video and sound. For example, direct instruction can feature videos of processes or situations. Projects and experiments can involve graphic representations of data and more efficient data collection and analysis, especially in science classroom. Different types of learners can be reached through the use of technology. If used effectively, technology can greatly enhance learning. In order to inculcate the necessary scientific knowledge, skills, competencies and attitudes, various development and strategies are put in place in Nigeria educational system (FRN, 2014a, 2014b).

Computer simulations provide an interactive and visual environment that promote and support conceptual change in chemistry education. The usage of simulation teaching packages in scientific classes according to Asogwa et al. (2016), has been demonstrated to improve student progress and may eventually yield favorable outcomes. Obafemi and Macaulay (2022) discovered a significant difference between the retention ability of students taught Chemistry using the Simulation Instructional strategy and those taught using Teacher-demonstration, in favour of the Simulation Instructional strategy. In a study based on the instructional use of computer simulation for learning genetics. The result of the study shows that the computer simulation instructional strategy significantly improves the attitude of students towards biology (Akhigbe & Ogufere, 2020). Likewise Agu and Samuel (2018) revealed that there exists significant difference in the achievement and retention of students taught using Simulation Instructional Package. When used as an instructional method, it bridges the gap between reality and abstract knowledge. Nwobasi and Nwani (2020) discovered that Videotape instructional package significantly improved students' retention of Chemistry concepts than the traditional method. The result of their study is in agreement with the findings of Eze et al. (2020) who similarly reported that multimedia technology improved students' ability to retain knowledge.

Science education through simulations yields beneficial effects over time and allows students to modify variables or parameters and examine the results of their activities (Umoke & Nwafor, 2014). In conclusion, proponents affirm that computer simulations promote students' interest and involvement, foster retention of information, and offers opportunities for affective and behavioral learning. Furthermore, those in favor of the use computer simulation in higher education contend that through repeated practice and immediate feedback, transfer of knowledge, skills, and abilities from classroom to real world environments is enhanced.

Video instruction was greatly transformed following the development and increased interest in 'anchored instruction.' Along with the commercially created and published videos, movies created by teachers present another form of video technology. Majority of instructor-created clips are content relevant to learner needs and include modeling example or non-examples as well as self-modeling techniques. Video in particular is often attractive as a means to capture lecture content and present direct instruction. It is indeed a powerful medium, but as with anything else, video must be created with an eye for strong pedagogical choices in order to remain effective. Most studies conducted are on videotape instruction, for instance, Saratu et al. (2020) examined effects of video based instructional package on achievement of secondary school biology student.

Computer simulation and Video media package as an instructional strategy gives the learner the privilege to participate, control and, study at a close pace until the learning is achieved. The current study set out to ascertain the impact of computer simulation and video media instructional packages on students' attitude, performance, and memory of chemical ideas, as well as the degree of classroom engagement. The specific objectives of the study are to;

a. examine the relative effectiveness of computer simulation and video media instructional packages in improving students' performance;
b. compare students' attitude towards Chemistry using the two packages; and
c. examine the relative effectiveness of the two packages in enhancing students' retention of Chemistry concepts.

Research questions

a. what is the relative effectiveness of computer simulation and video media instructional packages in improving students' performance;
b. what is the level of students' attitude towards Chemistry using the two packages
c. how effective are the two packages in enhancing students' retention of Chemistry concepts.

Research hypotheses

The following research hypotheses were developed for the study;

1. There is no significant difference in computer simulation and video media instructional packages in improving students' performance in Chemistry in Ife Central Local Government Area;
2. There is no significant difference in students' attitude towards Chemistry using the two packages; and
3. There is no significant difference in the two packages in enhancing students' retention of Chemistry concepts.

Literature review

Chemical education: it's importance and challenges

The poor performance in Chemistry has been traced to several factors which may include the methods of teaching employed by the teachers which is not in line with the modern methods that involves the use of information technology and some other novel and interesting methods that can make the students to learn the subject meaningfully (Bamidele & Oloyede, 2013). In order to make Chemistry real and relevant in Nigeria, Chemistry teachers should motivate their students by adopting teaching strategies in which they are made to participate actively in lesson and using local and familiar materials in illustrating scientific facts and principles related to Chemistry. This is because Chemistry, as a physical science can be taught and learned most effectively if its teaching involves hands—on and mind-on or activity—centered or subject-centered, rather than lecture method or *"chalk and talk"* method which is teacher–centered (Ominowa & Bamidele, 2016).

Agulana and Nwachukwu (2001), pointed out that much of what is learnt in school is through rote learning whereby students learn statements or formulae directly from the teachers or textbooks and reproduce such information on cue. Such students, they said are unable to use their learning outside the classroom. Chemistry being one of the core sciences subjects in the national education curriculum and studied alongside other related basic science subjects such as Biology, Physics and Mathematics. Amaefule (2001) opined that 'Chemistry is a subject which is very ideal for inculcating in students the virtues of honesty, critical thinking, spirit of inquiry, cooperative attitudes and the ability to observe nature consciously and logically'. The relevance of Chemistry among the basic science subjects is apparent; therefore, there is the need for it to be taught properly in the secondary schools to enhance students' understanding and improve their grade in both internal and external examinations. This will definitely increase their chances gaining admissions into institutions of higher learning

According to Onwu (1991), teachers of Chemistry are expected to make Chemistry more relevant, enjoyable, easy and meaningful to students. Literature shows that teachers still hold up to the use of expository or didactic teaching method in Chemistry classroom (Adesoji et al., 2006). This method of teaching leads to rote learning of facts, concepts and principles which is far away from the scientific principles of developing skills necessary for solving problems in the society. Ali (2002) asserted that Chemistry is an activity-oriented subject. It therefore requires the teachers to actively engage the students in practical work in Chemistry. He was of the opinion that, a significant difference in achievement exists between students taught through the "activity method" and those taught through the "lecture method". The lecture method is mostly valuable in stressing the main points but also keeps the learner passive and inactive in the teaching and learning processes; as the teacher lectures, students take notes, and then students are tested on what they have learned.

Students are found to have difficulties understanding chemistry concepts in the context that is set up based on traditional teaching strategies (de Jong & van Joolingen, 1998; Garnett & Treagust, 1992a). Njoku and Ezeodurukwe (2015) are of the view that, the reason students find many Chemistry concepts difficult is the high level of abstraction of the concepts, and that teachers often do not have the necessary resources to make them more concrete.

Use of computer simulation in teaching

Simulations mimic real-world situations or objects. This could be because genuine objects are hard to come by, using real materials can be complicated, the concepts are abstract, or it takes a long time and great distance to obtain the materials. Simulation might prove to be a more advantageous option in any of the aforementioned situations. It is a well-established fact that many learners find it difficult to understand chemical concepts, because Chemistry is a multifaceted discipline, requiring complex thinking and reasoning (Kotoka, 2013). Computer simulation has long been acknowledged by Okwuduba et al. (2018) as a crucial component of education that deepens student understanding and enhance their achievement in chemistry. Bello et al. (2016) held a similar opinion, arguing that simulation programs improve teaching and learning by giving students real-world opportunities for tailored training, as well as by accelerating, enhancing, and deepening their skills and getting them actively involved in the process of learning. By incorporating more visual material into a Chemistry class, the teacher may succeed in restricting the overloading of the learner's

short-term memory, which many a times is the major factor leading to misconceptions. It is possible to acquire information through using computers and the internet in science, especially Chemistry classes of Secondary and Higher education. The teaching tools prepared by institutions specializing in such applications could also be used in virtual media. By using such teaching tools, learners could learn the subject matter in a better way, as they are provided with a variety of knowledge, and a medium where they can observe the virtual experiments and repeat the same experiments many times. As a result, it is expected that computer-assisted applications affect the learner's achievement (Morgil et al., 2005). Encyclopedia Britannica (2010) have shown that computer simulations provide learners conceptual assistance that leads to enhanced performance and retention of concepts learnt. Computer-Based Simulations (CBS) are an excellent way to demonstrate compelling, dynamic, and multidimensional learning ideas that are particularly difficult to explain through words, equations, or in-class experiments. When explaining the difficult ideas of organic chemistry, CBS with vibrant color and finely detailed visuals are useful (Mihindo et al., 2017). Students can learn and comprehend organic chemistry with the aid of the interactive simulation (Carpenter & Sullivan, 2017). According to Khaleel (2017), pupils who receive instruction via scientific simulations exhibit enhanced comprehension and positive attitudes towards chemical ideas compared to those who do not receive such instruction. Computer simulations support learners' ability to apply new concepts, improve professional thinking, and grow and widen professional knowledge. Student's remarked that computer simulation boosted their memory recall and that they enjoyed using the simulation learning tools according to study carried out by Olakanmi (2015). He suggested that chemistry educators use computer simulations to teach and learn chemistry concept. There was an important difference in the performance and retention ability of students educated utilizing Simulation instructional Package paralleled to that of the Conventional instruction approach (Agu & Samuel, 2018). In general, students who use simulations are more likely to demonstrate gains in chemistry knowledge. Nowadays, primary and secondary school students can use internet resources and software to mimic scenarios that might be challenging to explain or demonstrate in a classroom setting. While computers are widely used in Nigerian offices, research labs, publishing houses, and other settings, their application in secondary school education is rather small (Eniekebi, 2021).

Use of video media in education

The use of video in higher educational settings is accelerating rapidly in departments across all disciplines from humanities, science, and arts. Video can be used not only for teaching, but also for studying and learning in and outside the classroom. This indeed makes it a powerful medium, but as with anything else, video must be created with an eye for strong pedagogical choices in order to remain effective. Video package are instructional materials that use the stimuli of sight and hearing. By means of video, students could learn about lands and people they can never visit. As defined by Dantani (2011), Video is a potential window that can expose the minds and heart of students to scientific concepts. Video enhances comprehension and retention. In Nigerian secondary schools, as observed by Ominowa and Bamidele (2016) the most common method employed by Chemistry teachers is teacher–centered and is referred to as Classroom Demonstration Technique which involves the students sitting, listening and watching the teacher deliver the theoretical concept after which the teacher demonstrates the practical aspect to the students to see. Michelle (2013) reported that one benefit to using technology in schools is that learning can be enhanced with images, video and sound. Using videos in the classroom is a step in the right direction towards implementing and taking advantage of the available technology, and offer an additional visual for student learning. Achimugu (2013) agrees that students or activity-centered learning incorporating hands-on and mind-on activities can enhance chemistry knowledge acquisition. This will make chemistry more interesting to teach and learn, and will, as a result, improve students' chemistry achievement. Video package can be used as core or supplementary learning materials and can also teach difficult Science, Technology and Mathematics concepts. There is hardly any subject matter, which could not be taught effectively and learned when the individual considers the subject matter interesting. Dantani (2011) was of the view that, the video package gives the learner the ability to see and hear an instructor, offer opportunity for behavior modeling, demonstration and instruction of abstract concepts. It offers a popular easy-to-use format for instructional materials. Learning is the acquisition of knowledge and skills possible through systematic interaction between teachers and learners. It happens every day and involves teacher, learner and methodology and materials interaction. Parts of these materials are known as instructional resources (Afolabi & Akerele, 2012). Today multimedia is common among schools, offices and to every individual: It supports learning and helps in developing knowledge. The study by Eze et al. (2020), revealed that students taught by integrating multimedia in the teaching process recorded higher interest scores than their counterparts in the control group. Achimugu et al. (2022), also in their study found that students who taught chemistry using videotaped instruction performed better than students who taught chemistry using audio-taped

and expository instructional strategies and that students exposed to audio-taped instruction performed better than students exposed to expository instructional strategies. Umar et al. (2015) found that multimedia instruction enabled better retention in auto-mechanics than the conventional method. This proposition was buttressed by Nwobasi and Nwani (2020) and (Akhigbe & Ogufere, 2020) in their separate studies. Video based materials boost student creativity, cooperation and access to video can help motivate students and create a distinctive context for their learning experience.

Video tape recorders can be used in a number of different ways to enhance teaching and learning in both large groups and small groups. Combination of video and text makes sense, as it was believed that video is effective for more than simply showing dynamic processes. Video Instructional Package (VIP), is a medium of conveying information in a verbal and visual form to be displayed. The utilization of Video Instructional Package (VIP), is the foundation to meet the needs of todays and tomorrow's learners, Nwaokolo et al. (2022). Generally, it implies that video usage increases and enhances students' learning. Adetunji et al. (2012), reported that the combination of the Conventional Laboratory Technique and Video Media Instruction (VMI/CLT) strategy was more effective in enhancing students' achievement in practical chemistry than the conventional laboratory technique (CLT) and the Video Media Instructional strategies (VMI) separately, this result also coincide with the work of Yousef et al. (2014), who examined 67 peer reviewed papers from 2003 to 2013 that focus on video based learning and concluded that the use of video in teaching can improve learning outcomes as well as learning satisfaction. Gorissen et al. (2012) found evidence that studying recorded lectures during exam time increased the chance of students passing the exam although they point out that these results could be due to more active students being the ones who study the web lectures.

The issue here, though, is that different people have different ideas about how useful these mediums are for instruction and learning. According to conventional wisdom, learning through video media diverts students' attention. As a result, there are two schools of thought: those who believe that using multimedia in the classroom can improve student learning, and those who disagree and recommend against doing so (Ominowa & Bamidele, 2016). Another problem is that, even in schools with multimedia learning resources, the majority of students do not use them for instruction due to expensive maintenance and an inconsistent supply of electricity. These issues have caused students to rely solely on teacher instructions, and year after year, student performance, especially in the sciences and related disciplines, has been appalling. Additionally, in many schools where facilities are available, they are guarded closely and out of reach of the students, discouraging the students from using them for individualized learning. Finally, poor student attitudes and perceptions of science, particularly chemistry, have led many students to believe that Chemistry is an uninteresting, abstract, and difficult subject to understand.

Methodology

The study adopted the non-equivalent pre-test post-test control group research design. This method was adopted for the purpose of gathering information for describing and analysing information on the relative effectiveness of computer simulation and video-media instructional packages in improving learning outcomes of Chemistry students in Ife Central Local Government Area in Osun State. The independent variables in this study were two instructional packages i.e. Computer simulation and Video media as well as the Conventional method while students' learning outcomes (Achievement, Attitude and Retention) constituted the dependent variables. The video package used in this study was made by the researcher, while the computer simulation package used was downloaded and modified by the researcher to suit the purpose of the research study. The population for the study comprised 134,023 Senior Secondary (SS) students in Osun State.The sample is made up of 138 SS II Chemistry students in their intact classes selected from three secondary schools in Ife Central Local Government Area (LGA) in the State. The secondary schools were selected from the LGA using simple random sampling technique. The Senior Secondary Two (SS II) science class section was chosen through the use of purposive sampling technique from the three schools. The science class section of the SS II classes was assigned to two experimental and one control groups.Two research instruments were used to collect data for the study. Chemistry Achievement Test (CAT) and Chemistry Attitudinal Questionnaire (CAQ).

Validation of instruments

Chemistry Achievement Test (CAT)

In order to ensure the validity of the instruments used for the study, the initial draft of 40 items of the instruments was given to two Examiners of West African Examination Council (WAEC) to ascertain if the items measure the expected knowledge and correctness. Based on their comments, the researcher was asked to reframe wrongly constructed items and replace ambiguous items.

The reliability of the instruments was ascertained by administering it on SS II Chemistry students in their intact class from one school randomly selected outside the study sample. Their scores were analyzed to determine the level of difficulty index (p) of the test item. The difficulty indices obtained ranges between 0.37 and 0.69. Based on the validation process, fifteen (15) items were

dropped and twenty-five (25) items retained. The final set of 25 items was the CAT.

Chemistry Attitudinal Questionnaire (CAQ)

The purpose of the questionnaire was to elicit information on students' attitude to the learning Chemistry before and after the treatment. The researcher initially produced a draft of 30 items. The face and content validity of the items on CAQ were determined through experts' judgment in the Institute of Education, Obafemi Awolowo University, Ile-Ife, the research supervisor and another expert in Department of Science and Technology Education. They all reviewed the items in terms of relevance, sentence structure and adequacy of the instruments. Based on their comments, eight out of the total items were dropped. Corrections and suggestions made were effected to produce the final draft. An Exploratory Factor Analysis (EFA) was conducted using Principal Component Analysis (PCA) with Varimax rotation. The EFA yielded a 5-factor solution, explaining 65.7% of the total variance. The 5 factors represent distinct aspects of students' attitudes towards chemistry, including their attitude, learning strategies, perception of instruction, use of learning aids, and engagement and motivation. These factors provide a framework for understanding the underlying structure of the questionnaire.

The item-total correlation analysis was also conducted to evaluate the relationship between each item and the total score. The results showed all items have a reasonable strong relationship with the overall attitude towards chemistry.

The reliability of the questionnaire was determined using Crobanch alpha. A reliability coefficient of 0.73 was established. The value obtained was adjudged as good for the instrument. The Cronbach's alpha values for each dimension of the questionnaire structure indicates all dimensions have acceptable internal consistency ($\alpha \geq 0.70$). Dimension 4 (Use of Learning Aids) has the highest internal consistency, while Dimension 5 (Engagement and Motivation) has the lowest, but still acceptable.

Procedure for data collection

Data for the study were collected during normal school hours and permission was sought from the principals and subject teachers of the schools to allow the use of their schools. The researcher briefed them on the purpose of the study and they gave their full cooperation and assistance. The pre-test of Chemistry Achievement Test (CAT) was administered in the first week of the research exercise to all the students before the experimental groups were subjected to treatments. This is to ascertain the academic equivalence of the students before treatments. Two weeks after the pre-test, the researcher introduces the instructional packages which were presented to the experimental groups. Group A was exposed to Computer Simulation Package (CSP), where the researcher serve as facilitator, clarifying concepts, presenting the simulation material and engaging the students in active participation and manipulation of the simulation material. Group B was exposed to Video Media Package (VMP), where the researcher also served as a facilitator, clarifying concepts, answering questions and initiating feedback from the students. These packages were projected onto the screen for students to see.

> *At the end of the two weeks intervention, a post-test was administered on the students. Two weeks after the post-test, a retention test was administered to assess students' retention level.*

The data collected were analyzed based on the hypotheses using descriptive statistics and one way Analysis of Variance (ANOVA). Descriptive statistics were used to analyze the estimated marginal means, standard deviation and error estimates, ANOVA and ANCOVA was used to examine whether any significant differences exist among the groups.

Description of the computer simulation and video media packages used

The Computer Simulation and Video Media Packages used for the study focused on one of the most difficult aspect of Chemistry, which was Organic Chemistry. The Computer Simulation Package was a 3-dimentional tool that the teacher can manipulate during classroom interaction with the students. It provides a 3-dementional image of the various structures of organic compounds, which helps the students to have more insight into the concept of isomerism that they assumed to be abstract. Below are some of the simulated organic compound structures (Fig. 1).

The Video Media Package used in the study was a prerecorded video of the researcher teaching the same concept of organic chemistry.

Results

Hypothesis 1 There is no significant difference between computer simulation and video media instructional packages in improving students' performance in Chemistry.

Table 2 revealed ($F=13.607$, $p>0.06$) that there exists no significant difference in the pretest scores of those exposed to video media, computer simulation and conventional method.

To test the hypothesis, the post test scores of the respondents were subjected to analysis of covariance (ANCOVA) to ascertain if there was difference in the effectiveness of both instructional packages in the academic performance of the respondents.

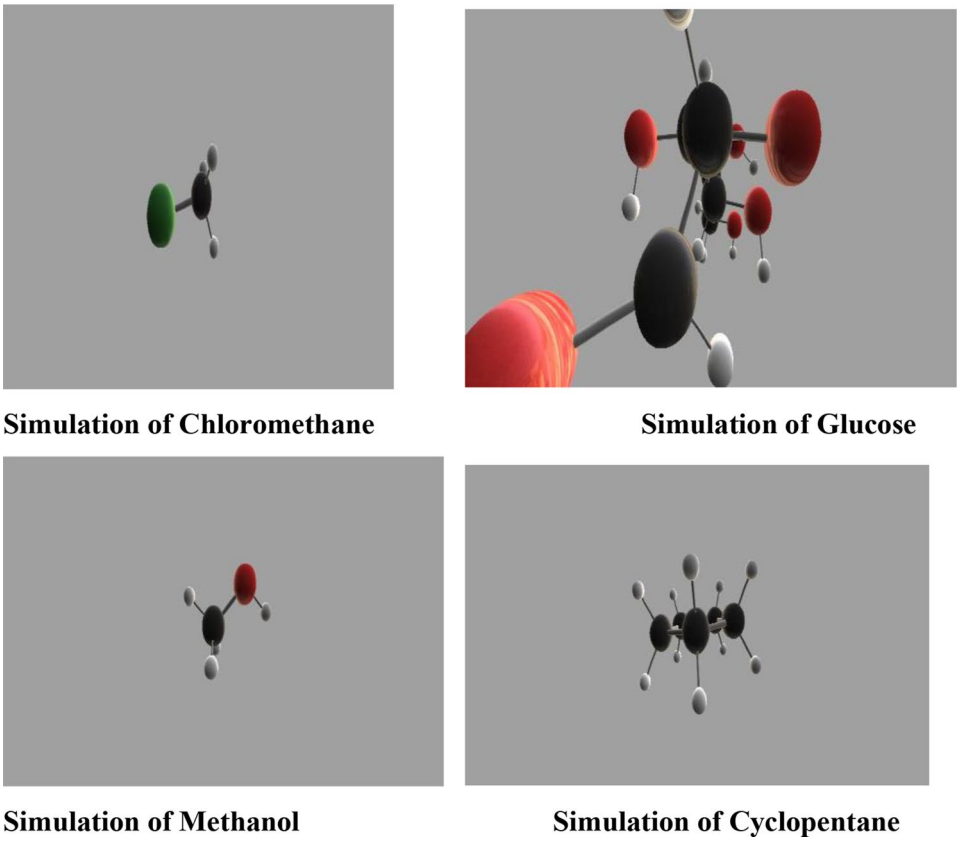

Fig. 1 Computer Simulation and Video Media Packages

Table 2 ANOVA table of pre-test scores of respondents

	Sum of squares	Df	Mean square	*f*	Sig.
Between groups	71.521	2	35.761	13.607	0.068
Within groups	354.798	135	2.628		
Total	426.319	137			

Source Field Survey (2023)

Table 3 ANCOVA table of post test performance of respondents

Tests between-subjects effects					
Dependent variable: scores					
Source	**Type III sum of squares**	**Df**	**Mean square**	***F***	**Sig.**
Corrected model	457.470	3	152.490	16.1703	0.000
Intercept	959.460	1	959.460	105.114	0.000
Pretest	37.409	1	37.406	4.097	0.45
Treatment	295.240	2	147.620	16.170	0.00
Error	1223.349	134	9.129		
Total	21433.000	138			
Corrected total	1680.819	137			

Note R Squared = 0.272 (Adjusted R Squared = 0.256)

Source Field Survey (2023)

The ANCOVA Table 3, where $F=16.170$, $p<0.05$, shows that there exists a significant difference in computer simulation and video media instructional packages in improving students' performance in Chemistry. Thus, the null hypothesis was rejected.

This was further buttressed in Table 4, as those exposed to the computer simulation package have the highest post test score of 13.63 while those exposed to the conventional method have the lowest post test score of 9.46. It could be deduced that the computer simulation package is the more effective of the two packages in improving students' performance in Chemistry (Fig. 2).

Hypothesis 2 There is no significant difference in the students' attitude towards Chemistry using the two packages. Here, the questionnaire responses of the respondents were summed giving a total highest possible score of 88. Strongly agreed was scored 4, agreed was scored 3, disagree 2 and strongly disagree 1. The total pre attitudinal and post attitudinal score of the respondents were subjected to Analysis of Co-variance (ANCOVA) to determine the difference in the attitude of students exposed to both packages.

The Table 5 revealed ($F=0.14$, $p>0.05$) that there is no significant difference in the students' attitude towards Chemistry using the two packages. It thus shows that students exposed to both computer simulation and

Table 4 Analysis of test scores

Package	Minimum score	Maximum score	Mean score
Video media			
Pre-Test	3.00	9.00	6.45
Post Test	6.00	18.00	12.08
Computer simulation			
Pre-Test	2.00	10.00	6.14
Post Test	7.00	19.00	13.63
Conventional			
Pre-Test	1.00	8.00	4.71
Post Test	6.00	15.00	9.46

Source Field Survey (2023)

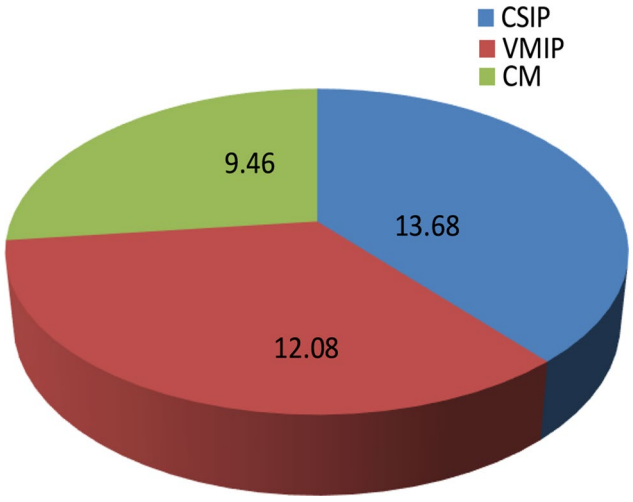

Fig. 2 Representation of analysis of post-test scores of respondents

Table 5 ANCOVA table of attitude of students

Tests between-subjects effects					
Dependent variable: attitude					
Source	**Type III sum of squares**	**Df**	**Mean square**	***F***	**Sig.**
Corrected model	53.564[a]	3	17.855	2.023	0.114
Intercept	3470.123	1	3470.123	393.255	0.000
Pre attitude	52.225	1	52.225	5.918	0.016
Treatment	0.253	2	0.127	0.014	0.986
Error	1164.782	132	8.824		
Total	248145.000	136			
Corrected total	1218.346	135			

Note R Squared = 0.044 (Adjusted R Squared = 0.022),

Source Field Survey (2023)

[a]Significant difference between the two packages in comparison

video media packages did not significantly vary in their attitudes.

Hypothesis 3 There is no significant difference in the effectiveness of the two packages in enhancing students' retention of Chemistry Concepts. The retention score of the respondents was also subjected to analysis of Covariance.

Table 6 ANCOVA table of retention of students

Tests between-subjects effects					
Dependent variable: retention					
Source	**Type III sum of squares**	**Df**	**Mean square**	***F***	**Sig.**
Corrected model	520.734[a]	3	173.578	18.326	0.000
Intercept	1614.812	1	1614.812	170.484	0.000
Pretest	11.333	1	11.333	1.196	0.276
Group	381.762	2	190.881	20.152	0.000
Error	1269.237	134	9.472		
Total	28894.000	138			
Corrected total	1789.971	137			

Note R Squared = 0.291 (Adjusted R Squared = 0.275)

Source Field Survey (2023)

[a]Significant difference between the two packages in comparison

Table 7 Descriptive statistics of retention of respondents in the groups

Group	*N*	Minimum	Maximum	Mean	Std. deviation
Video retention	38	12.00	20.00	14.7895	2.49495
Computer retention	59	8.00	22.00	15.5424	3.72004
Conventional retention	41	8.00	19.00	11.0976	2.48802

Source Field Survey (2023)

It was revealed that ($F=20.152$, $p<0.05$). This shows that there exists a significant difference in the effectiveness of the two packages in enhancing students' retention of Chemistry Concepts. Thus, the null hypothesis was rejected. To further ascertain this hypothesis, the retention score of the respondents was analyzed (Table 6).

The table above revealed a mean retention score of 14.79 for video media package, 15.54 for Computer simulation package and 11.10 for the conventional method (Table 7).

This showed that those exposed to Computer simulation package have the highest retention in the group.

Discussion

This study analyzed computer simulation and video-media instructional packages in improving learning outcomes of Chemistry students in Ife Central Local Government Area in Osun State. The following discussions were made based on the results obtained from the analysis presented in Tables 1–6.

The analysis of the pretest scores of the respondents shows that there were no significant differences in the three groups. The analysis of the post test score shows that those taught with the computer simulation package have the highest mean post test score of

13.68 while those taught with video media package have 12.08 and conventional teaching method have 9.46. Also, the post test score of the respondents were subjected to ANCOVA to determine most effective package in improving students' performance in Chemistry. The result reveals that $F=16.170$, $p<0.05$, indicates that there exists a significant difference in the effectiveness of the two packages in improving students' performance in Chemistry. Findings from the study suggested that computer simulation instructional package is more effective followed by video media instructional package and then conventional teaching method being the least effective. Kalyuga (2008) opined that novice learners benefit more from static diagrams than from simulated diagrams. Whereas more knowledgeable learners benefit more from simulated rather than static diagrams. This could be why computer simulation was more effective. Simulations technique seems useful for simulating abstract concepts, labs that are impractical, expensive, impossible, or too dangerous to run. Computer simulations can contribute to conceptual change (Steffes & Duverger, 2012); provide open-ended experiences for students, provide tools for scientific inquiry and problem-solving experiences. Computer simulated instruction give students the opportunity to observe a real-world experience and interact with it, (Sahin, 2006). In chemistry classrooms, simulation can play an important role in creating virtual experiments and inquiry. Problem based simulations allow students to monitor experiments, test new models and improve their intuitive understanding of complex phenomena. This finding concur with the study that looked at how using computer simulation affected students' performance in chemistry at the senior secondary school level and found that it is a useful tool for improving students' performance in chemistry and encouraging meaningful learning (Oladejo & Victoria, 2021). Likewise Investigating the Effectiveness of Computer Simulations for Chemistry Learning (Plass et al., 2012), and Effect of Simulation on Students' Achievement in Senior Secondary School Chemistry in Enugu East Local Government Area (Ezeudu & Ezinwanne, 2013), but differ from that of Kotoka (2013) on Effects of Computer Simulations on the Teaching of Atomic Combinations to Grade 11 Physical Science Learners.

Furthermore, on students' attitude towards Chemistry using the two packages, result of the study shows that students' attitude does not significantly vary with the use of the two packages, which shows $F=0.14$, $p>0.05$. If students find chemistry concepts that they learn relevant, exciting and can relate it to their daily life and to the society in which they operate, there is a good chance that they will develop positive attitudes towards the subject. However, if students are not interested in Chemistry, they tend not to make an effort to learn and understand the meaning of concepts that are being taught to them. The non-variance in the attitude of the students could be as a result of the students enjoying the use of the two packages in learning as they wished they could see more of it being used in chemistry classroom. This, suggest that students broadly accept and use both packages as a means of computer- based instruction and as an enhancement of conventional teaching methods. This finding is in agreement with the work carried out by Vilia et al. (2017) that revealed that attitude has a significantly positive relationship with students' achievement. On the other hand, affective learning and motivation may be influenced strongly by the choice of media. This in turn, may influence how enthusiastically and successfully students engage in learning activities. Thus, video media and computer simulation can be an important media for motivation. As observed by Ercan (2014) in the study on the effects of multimedia learning material on students' academic achievement and attitude towards Science. It can also help to promote discussion and reflection about personal values, or personal connections to the topic under consideration. It can present visual information that is difficult to explain in other ways. Videos can be used to model positive behaviour and to motivate students. They are particularly useful for introducing a topic, or reviewing material already studied where motivation is a key to student involvement in a learning sequence. As suggested by Dagnew (2017) when investigating the relationship between students' attitudes towards schools, values of education, achievement, motivation and academic achievement. Computer simulation and video media can provide messages about issues critical to the lives of learners, or to the topic under consideration. They can also be designed to have strong emotional appeal. Thus, they can tap into emotional and values involvement with specific issues. With a careful concern about critical analysis of message design, information sources, the power of simulation and video to elicit emotional responses, videos can be effective for examining many different types of controversial issues and promoting class discussions on them. Indeed, the aforementioned have indicated that it is easy to attract students' interest and attention with the use multimedia.

On retention, the study revealed that those exposed to Computer simulation package have the highest retention in the group with $F=20.152$, $p<0.05$ and mean retention score of 14.79 for video media package, 15.54 for Computer simulation package and 11.10 for the conventional method. This is in agreement with (Winn et al., 2006) study on Learning oceanography from a computer simulation compared with direct experience at sea, which observes that learners exposed to simulation seems to retain more of learnt concepts compared to the direct experience. Also, Ominowa and Bamidele (2016), in their

study found instructional media as highly interactive and effective in enhancing better retention of Chemistry concepts learnt.

This study adds to the body of evidence by demonstrating how computer simulations and video media can help students learn by providing them with a visual representation of the sometimes opaque and intricate conceptual realm of chemistry. This finding supports the notion that students often retain a great deal of visual information because they create and preserve a visual representation of it. This mental image helps students do better academically.

Conclusion

The study concluded that the computer simulation package was more effective of the two packages used in the study in improving students' performance in Chemistry. It could also be concluded that the two packages had significant effect on students' attitude towards chemistry, and that students exposed to the computer simulation package retained classroom knowledge (or learnt concepts) better than their counterparts exposed to the video media package.

Recommendations

Based on the study findings as well as the conclusion, this study recommends the following;

- Chemistry teachers should be trained and encouraged in the use of modern technology innovations in teaching, especially, multimedia in the teaching and learning process so as to reduce the challenges teachers face in explaining concepts in Chemistry as well as improve students' visualization as a process skill in Chemistry.
- Government should collaborate with software engineers to help develop low-cost educational software on simulations of various abstract chemical concepts in Chemistry that are relevant to Nigeria Senior Secondary School Chemistry curriculum.
- Multimedia skills should be included in the curriculum of secondary schools.

Contribution to knowledge

The findings of the study provided information on more suitable methods of teaching chemistry by making the lessons interesting, interactive as well as helping the students to perform better in Chemistry.

Students attitude towards Chemistry is greatly impacted as a result of use computer simulation and video media in the classroom. They can see, observe, and/or visualize while manipulating the provided information. This help foster high degree of involvement and collaboration among students.

When retention is improved, as it is with the use of CSIP and VMIP, students can learn outside and practice what they have learned until they are satisfied or excellent and their learning goals are reached.

Limitation of the study

This research was limited to chemistry, but it has the potential to cover a greater geographic area and other areas, particularly the sciences. Since the respondents had a hectic schedule, it took longer for the study to reach them also most of the teachers tasked to help in the study, actually found the use of technology challenging. Finally, due to unforeseen circumstances, the original data was lost, preventing the performance of Confirmatory Factor Analysis (CFA). While alternative analyses (Exploratory Factor Analysis and Item-total correlation) were conducted to assess the instrument's validity, the absence of CFA limits the certainty of the findings. Future research should prioritize CFA to confirm the factor structure and enhance the validity of the instrument.

Suggestion for further study

The present study was conducted using Chemistry subject. Therefore, the findings could not be generalized to other subject areas. Hence, there is need for more in-depth studies to be carried out in other subject areas such as Biology, Physics, Mathematics to provide more suitable methods of teaching those subjects for students' learning. Furthermore, studies should be conducted on effective ways educators can use technology to ameliorate teaching-learning activities while using wider geographical area.

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Author contributions

E.O. Fabeku, Initiate and organized the manuscript, he was the major writer of the manuscript. S.C. Enyeasi collect and analysed all the data used in the manuscript and also the major contributor in writing the manuscript. The authors read and approved the manuscript.

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