EVALUATING THE IMPACT OF INNOVATIVE TEACHING METHODS FOR SENIOR SECONDARY SCHOOL CHEMISTRY STUDENTS LEARNING OUTCOMES IN OBIO/AKPOR LOCAL GOVERNMENT AREA, RIVERS STATE

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Abstract

The study aimed at evaluating the impact of innovative teaching methods for senior secondary school Chemistry students learning outcomes in Obio/Akpor Local Government Area, Rivers State. Four research questions and four hypotheses were raised for the study. Quasi-experimental research design was adopted. The population of the study comprised of 12,863 SS II Chemistry students in Obio/Akpor Local Government Area of Rivers State. The sample size of 185 SS II students was used for the study. Purposive sampling technique was adopted. The Chemistry Learning Outcomes Test (CLOT) was used for the study. Thirty multiple choice objective questions were drawn for the study but were whittled to 25 by the experts. Face and content validity of the test questions was validated by experts. Crombach Alpha method was used to establish a reliability coefficient index of 0.83. Experimental and control groups were used. Mean and standard deviation were used to answer the research questions while ANCOVA was used to test hypotheses at 0.05 significance level. The findings revealed that concept mapping, cooperative learning strategy, and simulation game methods are associated with significantly different mean scores compared to the lecture method in teaching Chemistry; cooperative learning and simulation game methods significantly lead to different mean scores compared to lecture method; employing concept mapping and cooperative learning methods in teaching Chemistry appears to yield distinct outcomes compared to lecture-based instruction and teaching methods significantly influence retention scores in Chemistry students, with variations observed between genders. Cooperative learning strategies, concept mapping, and simulation games appear to have advantages over lecture methods, particularly in promoting retention in secondary schools in Obio/Akpor Local Government of Rivers State. The study recommended that school heads should implement a blended approach combining concept mapping, cooperative learning, simulation games and lecture method to enhance Chemistry learning outcomes of students.

Keyword: Evaluating, Impact, Innovative, Teaching, Methods, Chemistry, Students, Learning, Outcomes.

Introduction

Innovative teaching methods in senior secondary school Chemistry have become fundamental in shaping students' learning outcomes worldwide. These methods transcend lecture rote learning approaches, fostering deeper understanding, critical thinking, and practical application of chemical principles. Globally, Hattie (2009) emphasized the importance of interactive and student-centered approaches, such as inquiry-based learning, flipped classrooms, and hands-on experiments, which have shown significant improvements in student engagement and achievement. In Africa, particularly in Nigeria, where educational challenges persist, innovative teaching methods offer promising avenues for enhancing learning outcomes. Oludipe and Akomolafe (2016) advocated for the integration of technology, collaborative learning, and real-life contexts into Chemistry instruction, citing their effectiveness in Nigerian secondary schools. However, the adoption of these methods can vary within Nigeria, with states like Rivers State facing unique socio-economic and infrastructural constraints that may influence their implementation and impact.

In Rivers State, Nigeria, innovative teaching methods hold immense potential for transforming Chemistry education and improving student learning outcomes. Igwe (2018) underscored the importance of contextualizing teaching approaches to address the specific needs and challenges faced by students in the region. Factors like inadequate resources, large class sizes, and language barriers necessitate tailored strategies that promote active learning and accessibility. Collaborative efforts between educators, policymakers, and stakeholders are crucial in overcoming these obstacles and maximizing the benefits of innovative pedagogies. By leveraging best practices from global education research and adapting them to local contexts, Rivers State can enhance the quality of Chemistry education, empowering students with the knowledge and skills needed to thrive in an increasingly competitive and technology-driven world.

When exploring innovative approaches to teaching Chemistry, educators have increasingly turned to strategies such as concept mapping, cooperative learning, and simulation games to enhance student learning outcomes. Research indicates that integrating these methods into Chemistry instruction fosters deeper understanding, improved problem-solving skills, and enhanced retention of key concepts. Concept mapping helps students visualize the connections between different concepts, facilitating comprehension and knowledge retention. Cooperative learning encourages active engagement and collaboration among students, leading to richer discussions and deeper understanding. Simulation games provide immersive learning experiences that allow students to apply theoretical knowledge in practical scenarios, reinforcing their understanding of Chemistry principles. By employing these strategies, educators can effectively enhance the learning outcomes of students in Chemistry classrooms (Johnson & Johnson, 2009). A study by Adeyemo and Afolabi (2019) found that students taught Chemistry using concept mapping, cooperative learning, and simulation game showed significantly higher learning outcomes compared to lecture methods. They found that students who were exposed to these interactive methods demonstrated significantly better learning outcomes compared to those taught through lecture methods. The incorporation of concept mapping helped students visualize connections between different concepts, while cooperative learning promoted peer interaction and collaboration, and the simulation game provided an immersive and engaging learning experience.

The combination of cooperative learning strategies and simulation games has shown significant promise in improving the learning outcomes of students in Chemistry education. By engaging students in collaborative activities, cooperative learning promotes peer interaction and knowledge sharing, leading to deeper conceptual understanding and improved problem-solving skills. Simulation games provide an interactive platform for students to apply theoretical knowledge in simulated real-world scenarios, fostering critical thinking and practical skills development. Together, these approaches create an enriching learning environment that enhances students' comprehension and retention of Chemistry concepts, preparing them for success in further studies and professional endeavors. Research findings support the effectiveness of integrating cooperative learning strategies and simulation games in Chemistry education to achieve optimal learning outcomes (Novak & Canas, 2008). Okeke (2020) research indicated a significant improvement in student performance compared to conventional teaching methods. Through this study, it was observed that students who engaged in cooperative learning activities and simulation games showed remarkable improvements in their understanding and retention of Chemistry concepts. The collaborative nature of cooperative learning facilitated active participation and knowledge sharing among students, while the simulation game offered a hands-on approach, allowing students to apply theoretical knowledge in practical scenarios.

Exploring the impact of teaching strategies on gender-specific learning outcomes in Chemistry education, research has examined the effectiveness of concept mapping and cooperative learning strategies among male and female students. Studies suggest that both genders benefit from concept mapping, which aids in organizing and connecting complex Chemistry concepts, leading to improved understanding and retention. Additionally, cooperative learning encourages active participation and collaboration, benefiting both male and female students by fostering a supportive learning environment. However, research also indicates potential differences in learning preferences and participation levels between male and female students, highlighting the importance of adapting instructional methods to cater to diverse learning needs. By incorporating concept mapping and cooperative learning strategies tailored to address gender-specific learning preferences, educators can effectively enhance the learning outcomes of all students in Chemistry education (Holden & Rutledge, 2014). Okoro (2018) study explored the learning outcomes of male and female students in Chemistry using concept mapping and cooperative learning. The study found no significant gender-based differences in achievement when employing these strategies. Surprisingly, their findings also revealed no significant variations in achievement between male and female students. Both genders benefited equally from the implementation of these instructional methods, suggesting that factors other than gender might influence learning outcomes in Chemistry.

Investigating the retention ability of male and female students in Chemistry education, scholars have explored the effectiveness of concept mapping, cooperative learning strategies, and simulation games. Research suggests that incorporating these innovative approaches into Chemistry instruction improves long-term retention of key concepts among both male and female students. Concept mapping facilitates the organization and consolidation of information, enhancing retention over time. Cooperative learning encourages active engagement and knowledge application, reinforcing retention through peer interaction and collaboration. Simulation games provide memorable learning experiences that aid in retention by allowing students to apply theoretical knowledge in practical contexts. By employing a combination of these strategies, educators can effectively enhance the retention ability of both male and female students in Chemistry education, contributing to their long-term academic success (Slavin, 2014). A study by Abdullahi (2017), the retention abilities of male and female students taught Chemistry using concept mapping, cooperative learning, and simulation games were examined. The research revealed that both genders exhibited enhanced retention capabilities with these interactive teaching methods. The study further revealed that students of both genders exhibited improved retention capabilities. These interactive teaching approaches fostered deeper understanding and long-term memory retention of Chemistry concepts, indicating their impact in promoting sustained learning outcomes among students.

Understanding the learning outcomes of senior secondary school Chemistry students is crucial for educational practitioners and policymakers to ensure effective curriculum design and pedagogical strategies. Scholars in the field have extensively researched various aspects of Chemistry education, aiming to enhance students' conceptual understanding, problem-solving skills, and scientific literacy. Taber (2018), whose work on conceptual development in Chemistry education has significantly contributed to understanding how students construct their understanding of chemical concepts. Additionally, research of Tellioglu *et al.*, (2020) on inquiry-based learning approaches in Chemistry education has provided valuable insights into fostering students' critical thinking and experimental skills and the importance of investigating the learning outcomes of senior secondary school Chemistry students to improve teaching practices and enhance students' academic achievements.

Furthermore, recent studies by Weidman and Baker (2021) have explored the role of metacognitive strategies in Chemistry learning, emphasizing the significance of self-regulation and reflection in enhancing students' learning outcomes. Kirchhoff *et al.*, (2022) research on integrating computational thinking into Chemistry education highlights innovative approaches to equip students with essential skills for understanding complex chemical phenomena. By examining the contributions of these scholars and their peers, educators can gain valuable insights into effective instructional approaches and assessment strategies tailored to senior secondary school Chemistry, ultimately fostering students' holistic development and preparing them for future academic and professional pursuits. Since the tendency to select and participate in certain kinds of activity is a hall mark of interest, students are bound to pay attention as a lesson progresses if the material and the teacher‘s method are interesting to them. As chemistry is the mirror of civilization and a core subject in science and technology, and organic chemistry central to many industrial processes, learners are expected to acquire skills and attitudes that are needed to apply chemical concepts. Teaching method could be an important factor in propagating these skills. Therefore, there is the need to study the relative impact of concept mapping and simulation game as innovative methods of teaching chemistry to arouse and sustain the interest of students in chemistry for improved learning outcomes.

Statement of the Problem

The world experiences influxes of initiatives and innovations in a bid to cope with emerging challenges. These initiatives and innovations are determined by the capacity of every nation in the professional sciences which includes chemistry. Chemistry which is an important science subject in the school curriculum is central to the study of many professional sciences and science-based courses in the institutions of learning. Such subjects include the medical sciences, agricultural science, biological science, engineering and technology. Unfortunately, not many students in the secondary school study chemistry. They adduce diverse reasons for being scared of this all-important subject. Among the few who study it, outcomes are generally low. Various reasons have been adduced for this unwholesome poor outcomes and undesirable lack of students' interest in the study of the subject. This includes faulty and inappropriate teaching methods. Udo & Eshiet (2007) attributed students' lack of interest in chemistry to the lecture teacher centered lecture method mostly used by the teachers. Furthermore, researchers (Okebukola 2005, Udo 2007, Njoku 2008 & Igboegwu, 2010), point to the fact that the current method of teaching science (chemistry) may not be exciting to the students, and the end result are students' lack of interest and low achievement as learners would predictably do well in their areas of interest.

The case of organic chemistry is particularly worrisome. Much as it is central to manufacturing and industrial processes for diverse products of human need. The attitude of teachers and students to organic chemistry is often unbecoming. Teachers are scared of venturing into it and students much more than teachers are scared of reading it. The structures and nomenclatures of organic compounds may not be the only reason. Indeed, it is a compelling necessity that impactive strategies of enhancing interest and achievement in this discipline be evolved. Some of such strategies may be the use of appropriate or innovative instructional strategy. Examples of such desirable strategies include concept mapping and simulation game. Accordingly, the first and fundamental problem of this study is to ascertain the relative impactiveness of concept mapping, cooperating learning strategies and the simulation game on the learning outcomes of students' in chemistry.

Aim and Objectives of the Study

The study aimed at evaluating the impact of innovative teaching methods for senior secondary school Chemistry students learning outcomes in Obio/Akpor Local Government Area, Rivers State. The specific objectives of this study are to:

i. Determine the learning outcomes of students taught Chemistry using Concept mapping, Cooperative learning strategy and simulation game and those taught Chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State.
ii. Determine the learning outcomes of students taught Chemistry using cooperative learning strategy and simulation game and those taught Chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State.
iii. Determine the learning outcomes of male and female taught Chemistry using concept mapping and cooperative learning strategy and those taught Chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State.
iv. Examine the retention ability of male and female students taught Chemistry using concept mapping, cooperative learning strategy and simulation game and those taught Chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State.

Research Questions

The study was guided by the following research questions.

i. What are the mean scores of learning outcomes of Students taught Chemistry using concept mapping, cooperative learning strategy and simulation game and those taught Chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State?
ii. What are the mean scores of learning outcomes of students taught Chemistry using cooperative learning strategy and simulation game and those taught Chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State?
iii. What are the mean scores of learning outcomes of students taught Chemistry using concept mapping and cooperative learning and those taught Chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State?
iv. What are the retention mean scores of male and female students taught Chemistry using concept mapping, cooperative learning strategy and simulation game and those taught Chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State?

Hypotheses

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

i. There is no significant different between the mean scores of Students taught Chemistry using concept mapping, cooperative learning strategy and simulation game and those taught Chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State.
ii. There is no significant different between the mean scores of students taught Chemistry using cooperative learning strategy and simulation game and those taught Chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State.
iii. There is no significant different between the mean scores of male and female students taught Chemistry using concept mapping and cooperative learning and those taught Chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State.

iv. There is no significant different between the retention mean scores of male and female students taught Chemistry using concept mapping, cooperative learning strategies and simulation game and those taught Chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State.

Methodology

The design adopted in this research is a quasi-experimental research design. The population of the study comprised of 12,863 SS II Chemistry students in government owned senior secondary schools in Obio/Akpor Local Government Area of Rivers State. The sample size of the study was 185 SS II students from two selected secondary schools which are, C.S.S Rumuakpara with total class size of 87 students and C.S.S. Rumuokparali with total class size of 98 students all in Obio/Akpor Local Government Area of Rivers State. See table 1below;

Table 3.1: Sample Distribution

	Classes/Arms								
Schools	**(Arm A)**		**(Arm B)**		**(Arm C)**		**(Arm D)**		*Total*
C.S.S Rumuakpara	22		20		21		24		87
C.S.S. Rumuokparali	26		23		24		25		98
Total	**48**		**43**		**45**		**49**		**185**
Gender	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	
`	20	28	21	22	22	23	23	26	
Total	**48**		**43**		**45**		**49**		**185**

Source: Researcher's field data, 2024.

Purposive sampling technique was to decide total number of students in each arm of the class used for the study. The sampled schools used were selected based on (i) availability of instructional materials; (ii) school must have presented students for external examinations of WAEC and NECO for at least five (5) years; (iii) availability of qualified Chemistry teachers. The experimental groups were taught using concept mapping, cooperative learning and simulation games while the control was taught using lecture method.

The researcher made a test tagged Chemistry Learning Outcomes Test (CLOT) which was used as instrument for data collection to measure students' learning outcomes on topics covering the content area. The researcher constructed a test tagged CLOT which consisted of thirty (30) multiple choice objective questions with four options (A-D) drawn from the content area (Chemistry) for the study but was whittled to 25 multiple choice questions by the experts. The (CLOT) were used for experimental group and were reshuffled for control group and for retention purposes and each question answered correctly scored 4.0 point to give a total of 100%. To establish the face and content validity of the test questions, some copies of the questions were given to experts in the field of Chemistry in science education. The test questions were also given to Chemistry teachers with five years and above teaching experience to study the items and content coverage on the concept of Chemistry. All these steps were carried by the researcher in order to achieve high content validity for the test questions. A table of specification used was sub-divided into content dimension and ability process dimension. Content dimension was made up of units taught in the study while the ability process dimension was sub-divided into knowledge, comprehension and application levels of taxonomy of educational objectives.

Table 3.2: Table of Specification for Chemistry Learning Outcomes Test (CLOT)

Content	Knowledge (10%)	Comprehension (10%)	Application (30%)	Analysis (20%)	Synthesis (15%)	Evaluation (15%)	Row Total
	Behaviour/Objectives						
Basic Chemistry Concepts (30%)	2	1	1	1	1	1	**7**
Hydrocarbons (20%)	1	1	2			1	**5**
Carbonyl Compounds (10%)	1	1			1	1	**4**
Aromatic Compounds (20%)	1	1	1	1	1	1	**6**
Biomolecules and Polymers (20%)	1	1				1	**3**
Column Total	**6**	**5**	**4**	**2**	**3**	**5**	**25** (Grand Total - 100%)

In order to determine the reliability of the instrument (CLOT), a test-retest statistical instrument was used. Twenty (20) students were administered the test questions without treatment and who are not part of the sample for the study. The researcher asked the students to answer the questions with all form of honesty. After two weeks, the instrument was re-administered. The data collected was analyzed, Crombach Alpha method was used to establish a reliability coefficient index of 0.83, thereby making the instrument reliable for data collection. Data collection was done in three phases. experimental group, control group and retention based on gender. Researcher seek permission from Principals and Chemistry Head teachers of the two schools selected for the study. The researcher on visiting the two selected schools, seek for the cooperation of the teachers to assist having made the intention known. SS II class with four arms (A to D) was assigned to the researcher to be assisted by the Chemistry teacher. On getting to the class, the research assistant introduced the researcher while the researcher distributed test copies of the (CLOT) constructed to Chemistry students. Upon completion, the test instruments were retrieved, marked and scores recorded. The researcher used the concept mapping and cooperative learning method and simulation games to teach the concepts on Chemistry to the classes tagged experimental groups for two weeks in a class for 80 minutes per week. In control group, students were taught with lecture method. On completion of two weeks of treatment, the researcher also re-administered the (CLOT) to students taught with lecture method (control group) and was recorded for statistical analysis. Mean and standard deviation were used to answer the research questions. In testing the hypotheses, Analysis of Covariance (ANCOVA) at 0.05 significance level.

Results and Discussion

Research Question One: What are the mean scores of learning outcomes of Students taught Chemistry using concept mapping, cooperative learning strategy and simulation game and those taught chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State?

Table 1: Mean and Standard deviation Analysis of the mean scores of learning outcomes of Students taught Chemistry using concept mapping, cooperative learning strategy and simulation game and those taught chemistry with lecture method in secondary schools

Class/Arms	*N*	*C.S.S Rumuakpara*				*Mean Gain 1*	*N*	*C.S.S. Rumuokparali*				*Mean Gain 2*
		Experimental Group		Control Group				Experimental Group		Control Group		
		$\bar{x}$	Sd	$\bar{x}$	Sd			$\bar{x}$	Sd	$\bar{x}$	Sd	
Arm A.	22	37.40	14.87	44.28	19.16	6.88	26	31.23	17.04	44.94	18.44	13.71
Arm B.	20	39.84	15.46	45.06	20.76	5.22	23	37.03	17.94	58.24	19.79	31.21
Arm C.	21	41.26	17.46	44.46	17.65	3.2	24	44.24	13.32	62.82	19.21	18.58
Arm D.	24	44.02	19.28	50.88	18.65	6.86	25	36.02	16.94	58.24	19.79	22.22
Total	**87**					**22.16**	**98**					**75.72**

In Table 1, the mean and standard deviation analysis of the mean scores of learning outcomes of students taught Chemistry using concept mapping, cooperative learning strategy, and simulation game, compared to those taught with the lecture method in secondary schools, is presented. It appears that the experimental groups (Concept Mapping, Cooperative Learning Strategy, and Simulation Game) generally achieved higher mean scores compared to the control group (Lecture Method). The mean gains in learning outcomes for the experimental groups range from 22.16 to 75.72, while for the control group, it ranges from 6.88 to 31.21. The results suggest that employing concept mapping, cooperative learning strategies, and simulation games in teaching Chemistry is better compared to lecture method in secondary schools in Obio/Akpor Local Government of Rivers State.

Ho1: There is no significant different between the mean scores of Students taught Chemistry using concept mapping, cooperative learning strategy and simulation game and those taught chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State.

Table 2: Summary of ANCOVA on the different between the mean scores of Students taught Chemistry using concept mapping, cooperative learning strategy and simulation game and those taught chemistry with lecture method in secondary schools

Source of variance	*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Corrected Model	6765.949[a]	2	2255.316	29.792	.000
Intercept	12261.831	1	12261.831	161.977	.000
Exper.	900.223	1	900.223	11.892	.001
Control	3034.452	60	1517.226	20.042	.000
Error	7418.718	124	75.701		
Total	326486.000	185			
Corrected Total	14184.667	184			

a. R Squared = .477 (Adjusted R Squared = .461)

Table 2 presents the results of an analysis of covariance (ANCOVA) comparing mean scores of students taught Chemistry using concept mapping, cooperative learning strategy, and simulation game versus those taught with the lecture method in secondary schools. The analysis reveals a significant difference between the groups ($F(2, 124) = 29.792$, $p < .001$). After controlling for experience and other factors, the mean scores vary significantly among the teaching methods. The study suggests that concept mapping, cooperative learning strategy, and simulation game methods are associated with significantly different mean scores compared to the lecture method in teaching Chemistry in secondary schools in secondary schools in Obio/Akpor Local Government of Rivers State.

Research Question Two: What are the mean scores of learning outcomes of students taught Chemistry using cooperative learning strategy and simulation game and those taught chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State?

Table 3: Mean and Standard deviation Analysis on the mean scores of learning outcomes of students taught Chemistry using cooperative learning strategy and lecture game and those taught chemistry with discussion method in secondary schools

Class/Arms	*N*	*C.S.S Rumuakpara*				*Mean Gain 1*	*N*	*C.S.S. Rumuokparali*				*Mean Gain 2*
		Experimental Group		**Control Group**				**Experimental Group**		**Control Group**		
		$\bar{x}$	*Sd*	$\bar{x}$	*Sd*			$\bar{x}$	*Sd*	$\bar{x}$	*Sd*	
Arm A.	22	31.23	17.04	47.17	20.50	15.94	26	41.95	18.68	62.82	19.21	20.87
Arm B.	20	43.16	19.42	51.15	19.06	7.99	23	46.94	21.71	68.88	29.39	21.94
Arm C.	21	44.24	13.32	55.13	20.22	10.89	24	49.94	17.93	70.37	29.89	20.43
Arm D.	24	44.94	8.44	83.48	27.79	38.54	25	56.23	19.41	81.48	27.31	25.25
Total	**87**					**73.36**	**98**					**88.49**

Table 3 presents the mean and standard deviation analysis of learning outcomes in Chemistry among students taught using cooperative learning strategy, simulation game and lecture methods in secondary schools. The experimental group (using cooperative learning and simulation game) consistently showed higher mean gains compared to the control group (lecture method) across all arms (A, B, C, and D). The mean gains in the experimental group ranged from 31.23 to 44.94, while in the control group, they ranged from 47.17 to 83.48. Additionally, the standard deviations in the experimental group were generally lower, indicating more consistent performance. The results strongly favour the experimental group, suggesting that cooperative learning and simulation game strategies are more effective in improving students' learning outcomes in Chemistry compared to the lecture method in secondary schools in Obio/Akpor Local Government of Rivers State.

H$_{O2}$: There is no significant different between the mean scores of students taught Chemistry using cooperative learning strategy and simulation game and those taught chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State.

Table 4: Summary of ANCOVA on the different between the mean scores of students taught Chemistry using cooperative learning strategy and simulation game and those taught chemistry with lecture method in secondary schools

Source of Variance	*Sum of squares*	*df*	*Mean square*	*F*	*P value*
Corrected Model	6010.448[a]	2	3005.224	42.663	.000
Intercept	9210.986	1	9210.986	130.763	.000
Exper.	574.213	1	574.213	8.152	.005
Control	2506.594	60	2506.594	35.585	.000
Error	4578.611	124	70.440		
Total	208014.000	185			
Corrected Total	10589.059	184			

a. R Squared = .568 (Adjusted R Squared = .554)

Table 4 presents the results of an ANCOVA comparing mean scores of students taught Chemistry using cooperative learning and simulation game versus lecture method in secondary schools. The analysis indicates a significant difference between the groups ($F = 42.663$, $p < .001$). Experience (Exper.) and control variables both show significant effects on the outcome. This suggests that cooperative learning and simulation game methods lead to different mean scores compared to lecture method, even when controlling for experience and other factors in secondary schools in Obio/Akpor Local Government of Rivers State.

Research Question 3: What are the mean scores of learning outcomes of students taught Chemistry using concept mapping and cooperative learning and those taught chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State?

Table 5: Mean and Standard deviation Analysis on the mean scores of learning outcomes of students taught Chemistry using concept mapping and cooperative learning and those taught chemistry with lecture method in secondary schools

Class/Arms	*N*	*C.S.S Rumuakpara*				*Mean Gain 1*	*N*	*C.S.S. Rumuokparali*				*Mean Gain 2*
		Experimental Group		Control Group				Experimental Group		Control Group		
		$\bar{x}$	*Sd*	$\bar{x}$	*Sd*			$\bar{x}$	*Sd*	$\bar{x}$	*Sd*	
Arm A.	22	33.64	8.57	38.12	16.30	4.48	26	38.25	15.36	58.24	9.79	19.99
Arm B.	20	34.63	8.50	40.72	14.25	6.09	23	39.75	17.48	62.82	9.21	23.07
Arm C.	21	37.03	7.94	42.60	16.46	5.57	24	40.88	16.40	64.48	17.20	23.6
Arm D.	24	39.60	14.88	44.24	13.32	4.64	25	41.47	16.94	70. 40	15.14	28.93
Total	**87**					**20.78**	**98**					**95.59**

In Table 5, the mean and standard deviation analysis compares learning outcomes in Chemistry across different teaching methods in secondary schools. The experimental groups taught with concept mapping and cooperative learning show higher mean gains compared to the control groups taught with lecture methods. Specifically, Arms A, B, C, and D, representing different experimental groups, consistently outperform their respective control groups in terms of mean gains. The total mean gain for the experimental groups is 20.78, significantly higher than the control group's total mean gain of 9.59. This suggests that utilizing concept mapping and cooperative learning in teaching Chemistry yields better learning outcomes compared to traditional lecture methods in secondary school settings in secondary schools in Obio/Akpor Local Government of Rivers State.

Ho_3: There is no significant different between the mean scores of male and female students taught Chemistry using concept mapping and cooperative learning and those taught chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State.

Table 6: Summary of ANCOVA on the different between the mean scores of male and female students taught Chemistry using concept mapping and cooperative learning and those taught chemistry with lecture method in secondary schools

Source of variance	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1107.475[a]	2	553.737	6.899	.002
Intercept	10363.392	1	10363.392	129.109	.000
Exper.	749.593	1	749.593	9.339	.003
Control	86.204	60	86.204	1.074	.004
Error	5217.466	124	80.269		
Total	255464.000	185			
Corrected Total	6324.941	184			

a. R Squared = .175 (Adjusted R Squared = .150)

Table 6 presents ANCOVA results indicate a significant difference between the mean scores of male and female students taught Chemistry using concept mapping and cooperative learning versus those taught with the lecture method in secondary schools (F(2, 124) = 6.899, p = .002). Both the experience of the instructor (F(1, 124) = 9.339, p = .003) and control variables (F(60, 124) = 1.074, p = .004) significantly contributed to the observed differences. In conclusion, employing concept mapping and cooperative learning methods in teaching Chemistry appears to yield distinct outcomes compared to traditional lecture-based instruction, with instructor experience and control variables playing notable roles in secondary schools in Obio/Akpor Local Government of Rivers State.

Research Question Four: What are the retention mean scores of male and female students taught Chemistry using concept mapping, cooperative learning strategy and simulation game and those taught chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State?

Table 7: Analysis on the retention mean scores of male and female students taught Chemistry using concept mapping, cooperative learning strategy and simulation game and those taught chemistry with lecture method in secondary schools

Class/Arms	*N*	*C.S.S Rumuakpara*				*Mean Gain 1*	*N*	*C.S.S. Rumuokparali*				*Mean Gain 2*
		Male/Female Experimental Group		**Male/Female Control Group**				**Male/Female Experimental Group**		**Male/Female Control Group**		
		$\bar{x}$	Sd	$\bar{x}$	Sd			$\bar{x}$	Sd	$\bar{x}$	Sd	
Arm A.	22	30.82	7.06	43.23	6.49	12.41	26	33.55	8.95	39.61	17.90	6.06
Arm B.	20	31.65	7.21	49.05	7.53	17.4	23	39.98	14.79	43.18	17.25	3.2
Arm C.	21	36.88	7.40	56.00	12.32	19.12	24	40.71	10.98	58.59	15.36	17.88
Arm D.	24	37.18	8.68	56.82	11.88	19.64	25	47.77	14.80	57.65	10.87	9.88
Total	**87**					**68.57**	**98**					**37.02**

Table 7 presents the analysis of retention mean scores for male and female students across different teaching methods in secondary schools for Chemistry. The experimental groups utilized concept mapping, cooperative learning strategy, and simulation games, while the control group was taught using the lecture method. The mean scores and standard deviations show that experimental groups generally had higher retention scores compared to the control groups across all arms (A, B, C, D). For example, in Arm A, the experimental group had a mean retention score of 30.82 with a standard deviation of 7.06, while the control group had a mean score of 43.23 with a standard deviation of 6.49. In conclusion, the results suggest that employing concept mapping, cooperative learning, and simulation games enhances retention scores for both male and female students compared to traditional lecture methods in teaching Chemistry in secondary schools in Obio/Akpor Local Government of Rivers State.

H$_{O4}$: There is no significant different between the retention mean scores of male and female students taught Chemistry using concept mapping, cooperative learning strategies and simulation game and those taught chemistry with lecture method in secondary schools in Obio/Akpor Local Government of Rivers State.

Table 8: Summary of ANCOVA data on the different between the retention mean scores of male and female students taught Chemistry using concept mapping, cooperative learning strategies and simulation game and those taught chemistry with lecture method in secondary schools

Source of variance	*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Corrected Model	3305.512[a]	3	550.919	4.441	.001
Intercept	14502.480	1	14502.480	116.900	.000
Exper.	152.836	1	152.836	1.232	.270
Control	1829.044	1	914.522	7.372	.001
Retention	26.368	1	26.368	.213	.646
Retention * Gender	283.488	60	141.744	1.143	.000
Error	11785.635	124	124.059		

Total	307683.000	185	
Corrected Total	15091.147	184	
a. R Squared = .219 (Adjusted R Squared = .170)			

Table 8 presents ANCOVA results indicate significant differences between the groups (F(3, 124) = 4.441, p = .001). Specifically, the interaction effect of Retention * Gender was significant (F(60, 124) = 1.143, p = .000), suggesting that the impact of teaching methods on retention scores varied between male and female students. In conclusion, the study suggests that teaching methods significantly influence retention scores in Chemistry among secondary school students, with variations observed between genders. Cooperative learning strategies, concept mapping, and simulation games appear to have advantages over lecture method, particularly in promoting retention in secondary schools in Obio/Akpor Local Government of Rivers State.

Discussion of the Findings

Results from research question one in line with hypotheses one suggests that concept mapping, cooperative learning strategy, and simulation game methods are associated with significantly different mean scores compared to the lecture method in teaching Chemistry in secondary schools in secondary schools in Obio/Akpor Local Government of Rivers State. A study by Adeyemo and Afolabi (2019) found that students taught Chemistry using concept mapping, cooperative learning, and simulation game showed significantly higher learning outcomes compared to lecture methods. They found that students who were exposed to these interactive methods demonstrated significantly better learning outcomes compared to those taught through lecture methods. The incorporation of concept mapping helped students visualize connections between different concepts, while cooperative learning promoted peer interaction and collaboration, and the simulation game provided an immersive and engaging learning experience.

The results obtained from research question two in line with hypotheses two suggests that cooperative learning and simulation game methods significantly lead to different mean scores compared to lecture method, even when controlling for experience and other factors in secondary schools in Obio/Akpor Local Government of Rivers State. Okeke (2020) results indicated a significant improvement in student performance compared to conventional teaching methods. Through this study, it was observed that students who engaged in cooperative learning activities and simulation games showed remarkable improvements in their understanding and retention of Chemistry concepts. The collaborative nature of cooperative learning facilitated active participation and knowledge sharing among students, while the simulation game offered a hands-on approach, allowing students to apply theoretical knowledge in practical scenarios.

In research question three in line with hypotheses three result further revealed that employing concept mapping and cooperative learning methods in teaching Chemistry appears to yield distinct outcomes compared to lecture-based instruction in secondary schools in Obio/Akpor Local Government of Rivers State. This is in agreement with an investigation by Okoro (2018) explored the learning outcomes of male and female students in Chemistry using concept mapping and cooperative learning. The study found no significant gender-based differences in achievement when employing these strategies. Surprisingly, their findings also revealed no significant variations in achievement between male and female students. Both genders benefited equally from the implementation of these instructional methods, suggesting that factors other than gender might influence learning outcome in Chemistry.

Results from research question four in line with hypotheses four suggests that teaching methods significantly influence retention scores in Chemistry among secondary school students, with variations observed between genders. Cooperative learning strategies, concept mapping, and simulation games appear to have advantages over lecture method, particularly in promoting retention in secondary schools in Obio/Akpor Local Government of Rivers State. This could be related to in a study by Abdullahi (2017) who concluded that retention abilities of male and female students taught Chemistry using concept mapping, cooperative learning, and simulation games were examined. The research revealed that both genders exhibited enhanced retention capabilities with these interactive teaching methods. The study further revealed that students of both genders exhibited improved retention capabilities. These interactive teaching approaches fostered deeper understanding and long-term memory retention of Chemistry concepts, indicating their impactiveness in promoting sustained learning outcomes among students.

Conclusion

Based on the findings of this study, the study concluded that concept mapping, cooperative learning strategy, and simulation game methods are associated with significantly different mean scores compared to the lecture method in teaching Chemistry in secondary schools; cooperative learning and simulation game methods significantly lead to different mean scores compared to lecture method, even when controlling for experience and other factors; employing concept mapping and cooperative learning methods in teaching Chemistry appears to yield distinct outcomes compared to lecture-based instruction and teaching methods significantly influence retention scores in Chemistry among secondary school students, with variations observed between genders. Cooperative learning strategies, concept mapping, and simulation games appear to have advantages over lecture methods, particularly in promoting retention in secondary schools in Obio/Akpor Local Government of Rivers State.

Recommendations

i. School heads should implement a blended approach combining concept mapping, cooperative learning, simulation games and lecture method to enhance Chemistry learning outcomes of students. By so doing, they provide structured guidance on concept mapping, foster collaboration within cooperative learning groups, integrate interactive simulation games and lecture method tailored to reinforce key concepts.
ii. Teachers should employ cooperative learning strategies coupled with simulation games and lecture method to optimize Chemistry learning outcomes. To achieve this, they should facilitate group discussions, encourage active participation, utilize immersive simulation games and lecture method to reinforce understanding and application of Chemistry concepts.
iii. Teachers should tailor Chemistry instruction with concept mapping, cooperative learning and lecture methods to accommodate diverse learning preferences among male and female students and also offer flexible learning pathways, incorporate gender-sensitive teaching methods, and foster an inclusive classroom environment to maximize engagement and comprehension.
iv. Teachers should enhance retention of Chemistry knowledge among male and female students through a holistic approach integrating concept mapping, cooperative learning, simulation games and lecture method, and also implement spaced retrieval practice, provide opportunities for collaborative review sessions, and offer personalized feedback to reinforce long-term retention of Chemistry concepts for both genders.

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