Faculty of Natural and Applied Sciences Journal of Mathematics and Science Education
Print ISSN: 2814-0885 e-ISSN: 2814-0931
www.fnasjournals.com
Volume 6; Issue 2; March 2025; Page No. 57-63.

Effects of Verbal Student-Made Models Strategy on Senior School Students' Performance in Organic Chemistry in Jos, Nigeria

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Abstract
The verbal student-made approach is based on Albert Bandura's (1977) observational learning theory, which proposed that learning is enhanced when concepts and ideas are slowly explained and described. To find out how verbal students' created models affected the organic chemistry performance of senior school II students, this study was conducted. For the investigation, two hypotheses and two research questions were developed. A quasi-experimental research approach was utilised, incorporating two pre-existing classes alongside a non-equivalent control group design. The study involved a total of 425 Senior Secondary II students specialising in chemistry within the Jos Metropolis, Nigeria. A total of 78 pupils were purposefully chosen to make up the study's sample. A control group and an experimental group were allocated to the classrooms for the verbal Student-Made Model technique. The chemistry teachers from the selected schools received training and were actively engaged in the study. Data collection was conducted using the Organic Chemistry Performance Test (OCPT), which demonstrated a reliability coefficient of 0.89. This assessment tool was developed by the researcher and subsequently validated by three subject matter experts. All of the hypotheses were evaluated using Analysis of Covariance (ANCOVA), and mean and standard deviation (SD) were used to analyse the gathered data. According to the study, students' performance differed significantly, regardless of gender, when taught organic chemistry using VSMS compared to the traditional technique ($F(1,75) = 32.85$, $p < .05$). It was suggested that the senior schools continue to employ verbal models created by students to teach and master organic chemistry principles.

Keywords: Performance, Organic Chemistry, Verbal Student-Made Model Strategy

Introduction

Chemistry teachers have a significant role in how learners will be able to realize the importance of chemistry to pursue chemistry and chemistry-related courses. Bandura (1977) suggested that humans learn from observing and imitating behaviour modelled by others. The author emphasised that observation and modelling are central to understanding how individuals acquire knowledge. The use of relevant strategies in chemistry is important to the learners' acquisition of knowledge and a deeper understanding of its application in society. These strategies are aimed at enhancing how students acquire and apply the knowledge of chemistry from the achieved learning objectives. A key factor in assessing whether learning objectives are met or not is the teacher's role as a learning designer. Teachers must be skilled and competent to plan learning activities so that they become challenging to meet learning objectives.

Using a verbal student-made models strategy will engage students in imitation of particular behaviours from the teacher, which encourages learning using models as stated in the Nigerian senior school chemistry curriculum. However, because it is easier to implement in senior schools, chemistry teachers frequently employ teaching strategies that do not develop students' thinking or skills. Students learn when concepts and ideas are explained patiently, which enhances learning (Nabavi, 2012). According to Blackie et al. (2023), organic chemistry is one area of chemistry that is challenging to teach and learn. From the preceding viewpoints, the effectiveness of the

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use of the verbal student-made models approach about secondary school pupils' performance in organic chemistry has yet to receive researchers' concerted effort and attention. The senior secondary school chemistry curriculum has recommended models to be used to teach the section on hydrocarbons, but this has not been fully practised by teachers and students (Stull et al. 2016; Pesce & King, 2023). Several researchers have reported that organic chemistry is difficult. Nartey and Hanson (2021), Adu-Gyamfi and Asaki (2023) and Nedungadi and Shenoy (2023) had identified organic chemistry to be difficult for students and a challenging task to teach by teachers. The authors suggested that teachers could use strategies that involve activity-based learning in lessons more than the conventional method.

Verbal student-made models' strategy (VSMS) has to do with learning involving the description or explanation of the learning material in words, patiently. Verbal student-made models strategy by Derakhshan et al. (2023) was suggested to be the step-by-step description of constraints and objectives that have been outlining to be achieved in teaching and learning. Bandura (1977) revealed that verbal students made a model strategy by watching what other people say to improve performance. Performance is the measure of achievement a learner has acquired in a given period. It is the measure of achievement of students of any educational system within a given period (Tadese et al., 2022). The measure of the performance of students in an educational organization and the skills that students have acquired is a measure of the achievement of that organization. The higher the number, the better the learning outcomes, and the lower the number, the poorer the learning outcomes. When a student's performance is high, it shows that the educational system is better, and, on the other hand, if the student's performance is low, the educational system is placed at a low level (Romadhoni et al., 2020). Studies have revealed that the gender issue in chemistry remains inconclusive. Nweke et al. (2022) found that organic chemistry should be taught irrespective of gender. However, Gongden (2023) reported greater performance in males than females.

Khalifa et al. (2020) examined how verbal interactions influence students' skill development and soccer performance within a cooperative learning framework based on socio-constructivist theory. The study identified two principal benefits of open verbalisation. Firstly, it acted as a social framework that facilitated both educators and learners in organising and refining their cognitive processes. Secondly, it contributed to critical self-evaluation of performance, enabling necessary modifications during activities related to the game. The study involved a sample of 30 ninth-grade students from a Tunisian school, comprising 12 girls and 18 boys, with an average age of 15 ± 0.4 years. Participants were assigned to either an experimental group, where verbal interaction was incorporated, or a comparison group that did not engage in verbal interactions. A pretest-posttest design was implemented before and after a structured 12-lesson soccer training program, conducted over approximately two hours per week.

To assess performance, the study utilised three skill-based evaluation methods: shooting accuracy, a 15-metre ball dribbling test, and the Loughborough Soccer Passing Test (LSPT). Additionally, overall game performance was measured using the Game Performance Assessment Instrument (GPAI), which examined key performance indicators such as skill execution (SE), game involvement (GI), support (S), decision-making (DM), and game performance (GP). Data analysis was conducted using ANOVA at a 0.05 significance level. The results indicated that although both groups exhibited notable advancements in short-passing proficiency, there was no equivalent improvement observed in dribbling and shooting skills. However, the experimental group, which engaged in verbal interactions, exhibited notable overall enhancements in game performance. Based on these results, the study concluded that physical education curricula should integrate cooperative learning strategies that emphasize team-based sports instruction, high-quality gameplay, and verbal engagement. These elements were identified as instrumental in enhancing students' tactical awareness and fostering reflexive learning.

Esparrago-Kalidas et al. (2023) conducted a study examining the effectiveness of verbal instructional modelling as a pedagogical intervention aimed at enhancing students' self-perceived confidence in their critical thinking skills. The study investigated the effectiveness of spoken instructional modelling in enhancing Grade 10 students' confidence in their critical thinking abilities in a private school in the Philippines. A practical action research design was utilized, incorporating a 6-point Likert scale questionnaire to assess students' self-reported confidence levels. The sample was selected through a convenience sampling technique, and data were collected both before and after the intervention. The analysis was conducted using a t-test to interpret the differences in students' confidence levels pre- and post-implementation. The findings revealed that verbal instructional

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modelling significantly improved students' perceived confidence in their critical thinking skills. Consequently, the study recommended the integration of verbal instructional modelling as a pedagogical strategy in classroom interactions to foster critical thinking development among students.

Nweke et al. (2022) examined the influence of the Hands-on Activity Learning Strategy (HALS) on students' academic performance and interest in Chemistry within Delta State, Nigeria. The study adopted a control group design, incorporating both pretest and posttest assessments. The research population consisted of 18,879 Senior Secondary II (SSII) Chemistry students from public secondary schools across the state. A total of 223 SSII Chemistry students were selected as the study sample. Data collection instruments included the Chemistry Interest Scale (CIS) and the Chemistry Achievement Test (CAT), which had reliability coefficients of 0.81 and 0.77, respectively. The collected data were analysed using mean scores, standard deviations, and t-test statistics. Findings indicated a significant disparity in both mean achievement and interest scores between students taught through HALS and those instructed via the lecture method (LM), with HALS demonstrating greater effectiveness. However, no statistically significant difference was observed in the mean achievement and interest scores of male and female students exposed to HALS. The study concluded that HALS is a superior instructional strategy compared to the traditional lecture method for improving students' academic performance and engagement in Chemistry. Consequently, it was recommended that Chemistry teachers in senior secondary schools integrate HALS into their instructional practices to enhance the teaching and learning of chemical concepts.

Gongden (2023) conducted a study on the application of a computer animation strategy (CAS) to examine the influence of gender on the performance and retention of Senior Secondary Two chemistry students. The research employed a pretest-posttest equivalent groups design, with three hypotheses formulated and tested at a significance level of 0.05. Data were collected from fifty students drawn from two coeducational schools, using the Chemistry Achievement Test (CAT) and the Mathematics Achievement Test (MAT). Based on their initial performance, the students were randomly assigned to two equally sized experimental groups, each consisting of 25 male and female students. Instruction on chemical equilibrium was delivered using the Chemical Equilibrium Achievement Test (CEAT) in conjunction with CAS. The study utilised thirty multiple-choice items sourced from past Senior School Certificate Examinations ($r = 0.78$) for data collection. The three research questions and hypotheses were analysed using mean, standard deviation, and a t-test ($\alpha = 0.05$). The findings revealed that while both male and female students exhibited significant differences in mean performance scores when taught using CAS, male students demonstrated statistically significant differences in retention scores. The study recommended employing a combination of instructional approaches for mixed-gender classes and the targeted use of CAS for enhancing male students' understanding of chemical equilibrium.

Research Questions

The following research questions were raised for the study:

1. How does the usual approach of teaching organic chemistry differ from the verbal student-made model by the students in terms of their performance?
2. How does gender affect students' performance when they are taught organic chemistry through verbal student-made models by students?

Hypotheses

The following null hypotheses were formulated and tested at the 0.05 level of significance:

$H0_1$: Students who are taught organic chemistry using verbal student-made models and those who are taught using the conventional technique do not significantly differ in their performance?
$H0_2$: When teaching organic chemistry utilising verbal student-made models, gender has no discernible impact on students' performance.

Methodology

This study adopted a quasi-experimental research design involving a pretest-posttest structure with a non-equivalent control group. The research was conducted using two distinct groups: an experimental group and a control group. Due to administrative constraints within the senior school system, random allocation of students into these groups was not feasible. Consequently, the study employed two pre-existing, intact classes to ensure

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practical implementation. All of the State Public Senior Secondary two pupils in Jos Metropolis, Plateau State, Nigeria, made up the study's population. There are 425 State Public Senior Secondary 2 (SS2) students in Jos Metropolis, Nigeria, who are enrolled in chemistry courses. A total of 78 students, comprising 35 males and 43 females, were selected from two pre-existing chemistry classes within Jos Metropolis. A purposive sampling approach was employed to identify and include two public, co-educational senior secondary schools in the study. OCPT contained 50 questions developed by the researcher to determine the level of performance of students on the topic of hydrocarbons. The instrument was developed from the topic of hydrocarbons senior secondary school chemistry curriculum. The OCPT items consisted of 50 objectives (multiple choice type) test questions, each with four alternatives (a-d) answer options. The test instrument was structured to align with the six cognitive domains outlined in Bloom's taxonomy, ensuring a balanced distribution of items across various instructional units through a table of specifications. Additionally, the Organic Chemistry Performance Test (OCPT) was designed to collect relevant demographic data on the students. The validation of the instruments was done by three (3) experts to determine the face and content validity of the instruments. A test and re-test reliability were carried out among senior secondary students outside the location of the study. This is to assess the instrument's internal consistency. Copies of the OCPT were administered to 20 respondents. Kuder-Richardson formula KR-21, which was used to determine the reliability coefficient for the OCPT which was found to be 0.89.

Chemistry teachers from the two sampled schools served as the researcher's two (2) research assistants. The research assistants from the chosen schools received training from the researcher at their respective educational institutions. To find out each group's pre-test performance levels, a pre-test was given to both groups and the control group. For the Experimental Group, the research assistant used the lesson plans to verbally describe and explain to the students how the structures of hydrocarbons are represented during student activities. Then project assignments of constructing structures of hydrocarbons using plasticine and plastic straw from the verbal instruction were given to the students. Then, the post-test was given to determine whether there was any change in their learning during the use of the student-made model's strategy. To address each research question, descriptive statistical methods, specifically the calculation of mean and standard deviation, were employed. The study hypotheses were tested using the Statistical Package for Social Sciences (SPSS) version 25.0, with a significance threshold of 0.05. Analysis of Covariance (ANCOVA) was applied to account for the influence of covariates, ensuring a more precise evaluation of the observed effects.

Results

Research Question 1: How does the usual approach of teaching organic chemistry differ from the verbal student-made model by the students in terms of their performance?

Table 1: Comparative Analysis of Pretest and Posttest Mean Performance Scores for Students in the VSMS and Control Groups

Group	N	Pretest Mean	SD	Posttest Mean	SD	Gained Mean Score	Mean Difference
VSMS	28	29.64	8.90	50.57	17.58	20.93	18.61
Control	50	32.48	7.48	34.80	11.05	2.32	

Table 1 illustrates the pretest and posttest mean performance scores for students in both the Verbal Student-Made Models Strategy (VSMS) group and the control group. The initial mean score for students instructed using VSMS was 29.64, with a standard deviation (SD) of 8.90, while the control group had a marginally higher mean pretest score of 32.48 and an SD of 7.48. After the intervention, the VSMS group demonstrated notable progress, attaining a posttest mean score of 50.57 (SD = 17.58), whereas the control group recorded a posttest mean score of 34.80 (SD = 11.05). The increase in mean scores, representing the difference between pretest and posttest results, was more pronounced in the VSMS group (20.93) in comparison to the control group (2.32), yielding a mean difference of 18.61 in favour of the VSMS approach. Furthermore, the standard deviation values suggest a greater distribution of scores within the VSMS group, particularly in the posttest phase, indicating variability in student performance improvements. Although both groups showed some degree of academic progress, the findings strongly suggest that the VSMS approach had a significantly greater impact on students' understanding of organic chemistry than the conventional teaching method.

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H01: When students are taught organic chemistry utilising verbal student-made models versus conventional methods, there is no discernible difference in their performance.

Table 2: Analysis of Covariance Summary Highlighting the Significant Variance in Performance between the VSMS and Conventional Teaching Groups

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	6474.022[a]	2	3237.011	19.710	.000
Intercept	2443.485	1	2443.485	14.878	.000
PRETEST	2009.494	1	2009.494	12.236	.001
GROUPS	5395.292	1	5395.292	32.852	.000
Error	12317.363	75	164.232		
Total	146488.000	78			
Corrected Total	18791.385	77			

a. R Squared = .345 (Adjusted R Squared = .327)

Table 2 above shows the analysis of results obtained for hypothesis 1, which was tested using ANCOVA. The result of the analysis reveals that the ($F_{(1,75)} = 32.85$, $p < .05$) was significant, as the p – p-value of .00 is less than the .05 alpha level. In favour of the VSMS group, the results demonstrate a significant variation in academic performance between senior secondary school students instructed in organic chemistry through the Verbal Student-Made Model Strategy (VSMS) and those taught using conventional pedagogical methods. Consequently, the first hypothesis was refuted, indicating that the implementation of VSMS had a more substantial impact on students' learning outcomes in organic chemistry compared to traditional instructional approaches.

Research Question 2: How does gender affect students' performance when they are taught organic chemistry through verbal student-made models by students?

Table 3: Comparative Pretest and Posttest Scores by Gender in VSMS Group

Group	N	Pretest Mean	SD	Posttest Mean	SD	Gained Mean Score	Mean Difference
Male	11	31.63	6.74	52.18	18.32	20.55	
							0.63
Female	17	28.35	10.03	49.53	17.57	21.18	

Table 3 illustrates the pretest and posttest performance outcomes for male and female students within the VSMS group in organic chemistry. The findings reveal that male students recorded a slightly higher pretest mean score (31.63, SD = 6.74) compared to their female counterparts (28.35, SD = 10.03). Both groups exhibited progress in the posttest, with male students attaining a mean score of 52.18 (SD = 18.32), while female students achieved a posttest mean score of 49.53 (SD = 17.57). The overall improvement, represented by the gained mean score, was marginally greater for female students (21.18) than for males (20.55), resulting in a mean difference of 0.63 in favour of female students. The elevated standard deviation values in the posttest scores suggest a wider range of performance variations following the intervention. These results indicate that although both male and female students benefited from the VSMS approach, female students demonstrated a slightly higher overall improvement in their comprehension of organic chemistry concepts.

$H0_2$: There is no significant influence of gender on the performance of students when taught organic chemistry using verbal student-made models.

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Table 4: Analysis of Covariance Summary Examining the Statistical Difference In Performance Between Male And Female Students In The VSMs Group

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	2948.760[a]	2	1474.380	6.833	.004
Intercept	494.302	1	494.302	2.291	.143
PRETEST	2901.775	1	2901.775	13.449	.001
GENDER	9.929	1	9.929	.046	.832
Error	5394.097	25	215.764		
Total	79952.000	28			
Corrected Total	8342.857	27			

a. R Squared = .353 (Adjusted R Squared = .302)

Table 4 above shows the analysis of results obtained for hypothesis 2, which was tested using ANCOVA. The result of the analysis reveals that the ($F_{(1,25)} = .05$, $p > .05$) was not significant, as the p – p-value of .83 is higher than the .05 alpha level. This result shows there is no significant difference in the performance male and female senior school students taught organic chemistry using VSMS. Hence, hypothesis 2 was accepted, implying that employing VSMS does not bring about different performance among students across genders.

Discussion

Based on research question one. The results revealed that students' performance in OCPT was better when taught using VSMS than the conventional method. This result may be connected to the verbal description, self-made models and understanding of abstract concepts such as the structures and structural arrangement of atoms of organic compounds. This finding is consistent with the findings of Khalifa et al. (2020) and Esparrago-Kalidas et al. (2023). Khalifa et al. (2020) reported that participants in a verbal interaction group exhibited notable enhancements in overall game performance. Similarly, Esparrago-Kalidas et al. (2023) found that the use of Verbal Instructional Modelling significantly boosted respondents' self-perceived confidence in their critical thinking abilities.

Regarding the impact of Verbal Student-Made Models Strategy (VSMS) on students' academic performance in organic chemistry, the study indicated no statistically significant difference between male and female students. Consistent with this, Nweke et al. (2022) observed that the performance of male and female students instructed through the Hands-on Activity Learning Strategy (HALS) did not vary significantly. However, this contrasts with the findings of Gongden (2023), who identified a substantial difference in performance between male and female students taught using Computer Animation Strategy (CAS), with male students demonstrating superior outcomes.

Conclusion

The findings of this study revealed that verbal student-made model strategy positively affected students' performance in organic chemistry. In conclusion, the use of verbal student-made model strategy significantly enhances performance in organic chemistry than the conventional method.

Recommendation

Therefore, this study recommended the continued used of verbal student-made model strategy in the teaching and learning of difficult concepts in organic chemistry.

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