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Effect of Computer Animation Instructional Package on Students' Achievement in Hybridization in Chemistry

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The study aimed to ascertain how learners' performance in the chemical hybridization concept was affected by the Computer Animation Instructional Package (CAI). A pretest-posttest quasi-experimental research design was used in the study. There were 120 seniors secondary school students in the sample. The control group received instruction via traditional lectures, while the experimental group was treated using computer animation. The Hybridization Achievement Test (HAT) and Students' Spatial Ability Test (SSAT) were tested and used for data collection. The tests had reliability coefficients of 0.71 and 0.77, respectively using Kuder Richardson 20. Using estimated marginal means and Analysis of Covariance (ANCOVA) at a 0.05 significance level, seven research hypotheses were tested. Results showed that CAI highly impacted students' performance in the chemical concept of hybridization. A noteworthy interaction effect between gender and spatial ability was also found, favouring females with high spatial ability over males with low spatial ability regarding learners' performance. The research results indicate that CAI enhanced students' performance on the hybridization concept in chemistry. The results also showed the gender-friendly and successful instructional characteristics of CAI.

Keywords: achievement, computer animation, conventional method, hybridization, spatial ability

INTRODUCTION

Learning the concept of hybridization gives students basic ideas about how bonds, molecular formulas, and structures are formed. It also provides the foundation for learning other concepts in chemistry. The interpretation and prediction of the hybridization state of compounds or molecules serve as important basic knowledge in learning most of the concepts in higher chemistry courses in Colleges and Universities. It is important to note that understanding the hybridization concept and being able to distinguish the types and bond angles are required to understand molecular geometry,

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organic and coordination chemistry, and chemical bonding. Salah and Demon (2011) averred that to understand hybridization, learners must make connections between several abstract quantum model concepts, including electrons, electronic density, molecular orbitals, linear combinations of atoms, atomic orbitals s and p, and orbital symmetry and overlap that adhere to symmetry principles. Nonetheless, several studies have indicated that one of the more challenging and esoteric ideas in chemistry at all levels is the idea of hybridization (Sallah & Dumon, 2011; Jian, 2015; Calis, 2018). In addition, learners have difficulty learning hybridization because they cannot understand the prerequisite concepts in chemistry (Zoller, 1990).

Among the important chemical concepts that aid students' understanding of hybridization are molecular, atomic orbitals, Hund's rule, and Pauli and Aufbau principles because they help better describe the electronic configuration of atoms and the basic rules or principles guiding it. According to Taber (2002), to completely understand how molecular orbitals are formed, learners must be able to describe the electronic structure of the simplest molecule. These cover understanding electrons in ground-state atomic orbitals and creating hybridized molecular orbitals through the overlap of atomic and molecular orbitals. Additionally, learners should be familiar with the various mathematical representations of atoms' orbitals, such as those of the s, p, d, and f, as well as hybrid orbitals, such as $sp^{3,}$ which are important for a learner to fully comprehend and make connections between these concepts related chemistry topics like molecular geometry, coordination, and organic chemistry (Nakiboglu, 2003; Calis, 2018).

Studies have shown that learners have little comprehension of the idea of hybridization because there is evidence that many cannot distinguish between atomic and hybrid orbitals (Hanson et al., 2012). The failure of students to distinguish between pure atomic and hybrid orbitals indicates a foundational difficulty in the prerequisite concepts (Hanson et al., 2012). Other weaknesses in hybridization include the inability to distinguish between single, double, and triple bonds in unsaturated and saturated hydrocarbon. Additionally, learners neglected to mention the importance of sp, sp2, and sp3 in identifying single and multiple bonds in hydrocarbon. Most students could not differentiate between the forms and types of hybridization in the molecules NH_3, OF_2, BCl_3, CO_2, C_2H_2, BeF_2, and C_2H_4 compounds (Abukari et al., 2022). They provided a graphic illustration that was erroneous and inadequate in explaining why water is not a linear molecule (Koomson et al., 2020).

More importantly, the West Africa Examination Council (WAEC) chief examiners' report in chemistry (2018-2020) reported that secondary school students in Nigeria performed poorly in hybridization and related concepts. The report revealed that students have weaknesses in electronic configuration, elemental analysis of organic compounds, and differentiation between ions and atoms, which are fundamental knowledge in learning the hybridization concept. In Nigeria, the concept of hybridization in secondary school chemistry is limited to comprehending atomic and hybrid orbitals and elucidating the creation of single, double, and triple bonds by the chemistry curriculum. Additionally, they are anticipated to ascertain the nature of the hybridization of the core atoms in molecules with various shapes. The curriculum allows the learner to learn the introductory aspects of hybridization, which is required for understanding hybridization, and related topics necessary for success in many chemistry courses in post-secondary education (Hanson et al., 2012). Given the relevance of hybridization, efforts should be directed toward students' poor performance (Koomson et al., 2020).

Because the traditional form of instruction widely used in schools cannot fully communicate the chemical world's representation of the hybridization concept, learners cannot learn it meaningfully in most Nigerian schools. This is not to say that the traditional method does not assist students; rather, it is insufficient to meet the needs of various learning style. A change in the instructional approach is required to address the learning demands of diverse pupils in the context of hybridization. Central to this change is the integration of technology into lecture methods that is widely used. The ideas of hybridization and atomic orbitals are abstract, much like many other chemistry topics, which makes them challenging to understand. As a result, it is imperative to implement efficient teaching techniques and combine them with the right technology teaching tools (Jian, 2015). In order to achieve improvements in hybridization learning outcomes, an instructional approach that makes it easier for learners to comprehend the structure of molecules in three dimensions must be used in the classroom. Such popular example is molecular models and information technologies (animation, simulation, and videos) (Calis, 2018). One of the cutting-edge teaching techniques that has been said to improve and inspire the successful teaching and learning of scientific ideas is computer animation.

To make learning hybridization more relevant and meaningful to students, an innovative strategy with technology like computer animation needs to be provided and well utilized. Furthermore, computer animation may help learners comprehend abstract concepts like hybridization. This can enhance and promote the successful teaching and learning of chemical concepts. Anekwe and Opara's earlier study from 2021 revealed that computer animation is a useful teaching aid that may enhance students' recollection of chemical subjects. According to Ikwuka and Samuel (2017), using computer animation can improve students' chemistry performance. This study therefore determined the effect of computer animation teaching package along with lecture method to improve students' understanding of the hybridization.

Apart from the methods of teaching, some variables or factors determine students' achievement in abstract chemistry concepts like hybridization; notable among them is the spatial ability, which is the ability or skill that helps students to reproduce or interpret chemical representation and gives students support and competency in comprehending symbolic and scientific representation. Many researchers have regarded this ability to directly affect the success of learners' in chemistry. For students studying chemistry, spatial skills are crucial (Harle & Towns, 2011; Savec et al., 2006). Making a good drawing of molecular and chemical representations and using them to explain physical and observable phenomena requires developing spatial abilities and good knowledge of chemistry content. According to Carlisle et al. (2015), chemical education and learning need spatial skills in theoretical ideas, processes, and molecular representations. According to Bailey (2007), animations can help learners understand more about the microscopic processes that occur in gases and improve their understanding of how these microscopic processes link to macroscopic processes. Furthermore, gender-related concerns have been identified as a factor affecting secondary school chemistry students' performance. According to Gambari et al. (2016), there have been mixed outcomes from studies addressing gender issues in science and mathematics. There is no correlation between a student's gender and academic achievement, according to some research, however there are notable variances in learning outcomes between male and female students (Yusuf, 2004). Therefore, this study looks at the impact of gender and spatial ability as moderating variables on learners' performance in besides assessing the efficacy of the treatment.

Hypotheses

At the significance level of 0.05, the following null hypothesis was developed and put to the test.

Ho_1: There is no significant main effect of treatment on learners’ performance in hybridization concept

Ho_2: There is no significant main effect of gender on learners’ performance in hybridization concept

Ho_3: There is no significant main effect of spatial ability on learners’ performance in hybridization concept

Ho_4: There is no significant interaction effect of treatment and gender on learners’ performance in hybridization concept

Ho_5: There is no significant interaction effect of treatment and spatial ability on learners’ performance in hybridization concept

Ho_6: There is no significant interaction effect of gender and spatial ability on learners’ performance in hybridization concept

Ho_7: There is no significant interaction effect of treatment, gender and spatial ability on learners’ performance in hybridization concept

METHOD

A 2 x 3 x 2 factorial matrix, quasi-experimental pretest-posttest control group design was used for the investigation. The participants were senior secondary school II students enrolled in chemistry classes in Kwara state's Irepodun local government area. Omu Aran and Aran Orin are the two significant settlements in the local government chosen for the research. The criteria for selection of the two towns are as follows: one of them is the capital while the other is the closest to the capital. The rationale for this is that the nature of the treatment requires the availability of ICT and the Internet, which is not readily available in schools far away from the local government capital. Four schools with sufficient systems and electricity supply were selected in each town. The treatment and control were randomly allocated to the selected schools in each town. The SSII students were chosen for the study because they already understood some of the key notions that would have allowed them to understand the concept of hybridization, which will provide them with the foundational knowledge they need to understand more advanced chemical concepts. The participants were 120 Senior Secondary School two students, 64 of whom were in the experimental group and 56 of whom were in the control group. There were 66 female and 54 male students among them.

Instruments

The instruments used to gather the data were the Hybridization Achievement Test (HAT) and the Students' Spatial Ability Test (SSAT). The HAT was divided into two divisions, A and B. Section A had private information such as the name of the school, class, and sex, and section B contained 40 multiple-choice questions with alternatives A–D for each question. The 30 items on the SSAT aim to assess students' spatial ability.

Validation of Instruments

The HAT and SSAT instruments' face and content validation were done by specialists in the University of Ibadan's Department of Science and Technology Education. To validate the test items, pilot testing was conducted on 20 students from a school not included in the main study. Using Kuder Richardson's formula 20 (KR20) to assess the results of the pilot testing for both instruments, the reliability coefficients for HAT and SSAT were found to be 0.71 and 0.77, respectively.

Treatment Procedure

The computer animation package for teaching hybridization was installed into the computers in the computer laboratory of each school in the treatment group. Each student logs into the computer, and immediately, the students click on the package, and the interface in Figure 1 is seen. There are four lessons in the package. There is a quiz after each lesson. The next step is for the pupils to click on each lesson in turn. Furthermore, Back, Home, and Continue are the three command buttons.

Figure 1
The package contains four lessons

Description of Graphic Text

The first lesson consisted of two units. Unit one provided a textual and diagrammatic explanation of the atomic orbital and its types. The diagrams are able to move when clicked to indicate the movement of electrons. The second portion of the lesson covered the fundamentals of electronic configuration and how to choose which orbital to put an atom's electron in by applying the Aufubau, Pauli Exclusion, and Hund's rule of multiplicity concepts.

Lesson two provided explanations and vivid examples of writing the electronic configuration of atoms given their atomic numbers. The correct and incorrect application of the three principles were illustrated diagrammatically using the electronic configuration of different atoms. Students were introduced to the concept of hybridization in the third lesson. The types of hybridizations were also illustrated through animations and diagrams. The bond angles of various types of hybridization were equally illustrated in the animation. The process underlying the development of various hybrid orbitals is explained and shown in lesson four.

Description of Animation in the Lessons

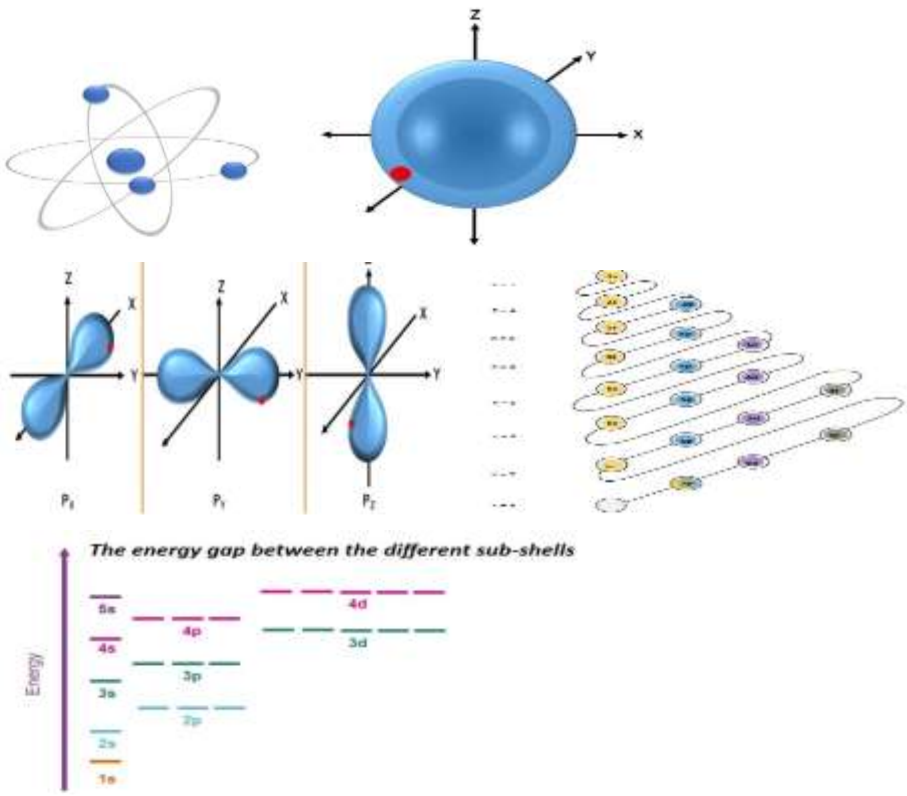

Figure 2
Shows the animation of shapes for s-orbital and p-orbitals in a diagrammatic form

The figure 2 shows the animation of shapes for s-orbital and p-orbitals in a diagrammatic form, illustration of Aufbau and the energy gap between different sub-shells.

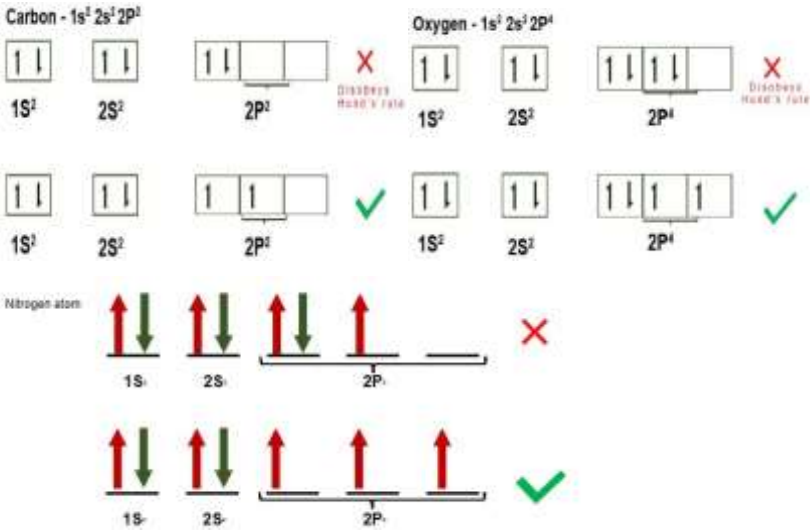

Figure 3
Shows the package animations of writing the correct electronic configuration of atoms of elements

Figure 3 illustrates the package animations of writing the correct electronic configuration of atoms of elements by giving due attention to the principle of spin quantum number. The incorrect and correct spin of electrons of atoms in their quantum boxes.

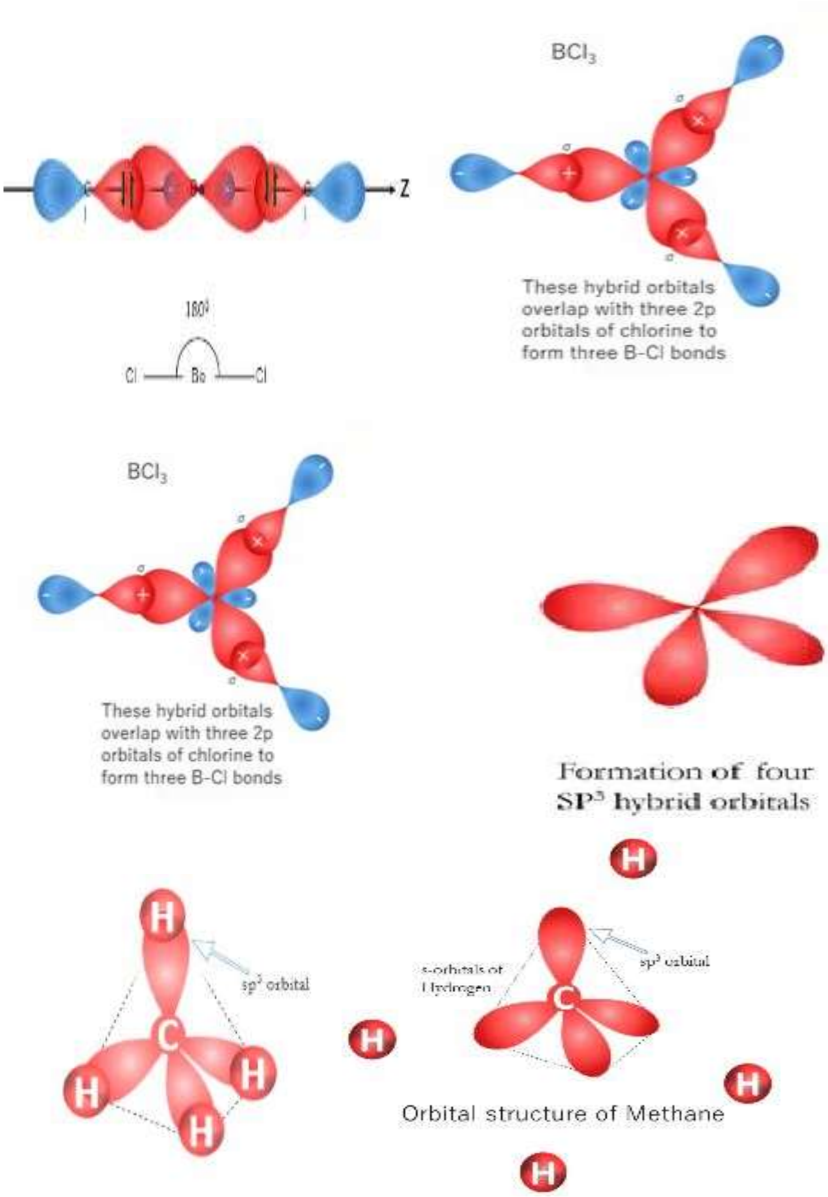

Figure 4
The formation of different hybrid orbitals as shown

The animation in the third lesson illustrates the formation of different hybrid orbitals as shown in Figure 4.

Data Analysis

Data obtained from the response instruments were analysed in line with the formulated hypotheses for the study. The pretest and posttest results for the experimental and control groups have been ascertained from the data collected. The pretest scores were used as covariates. The Analysis of Covariance (ANCOVA) was used to determine if there are main effects and interaction effects.

Ho1: There is no significant main effect of treatment on learners' performance in hybridization concept.

Table 1
Analysis of Covariance (ANCOVA) of Post-Achievement on treatment, gender and spatial ability

Test Between-Subject Effect

Dependent Variable: Post-Achievement

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	503.896[a]	12	41.991	6.271	.000
Intercept	800.523	1	800.523	119.560	.000
Pre-Achievement in Hybridization	50.145	1	50.145	7.489	.007
Treatment	246.599	1	246.599	36.830	.000*
Gender	.520	1	.520	.078	.781
Spatial Ability	.527	2	.263	.039	.961
Treatment*Gender	3.210	1	3.210	.479	.490
Treatment*Spatial Ability	27.351	2	13.676	2.042	.135
Gender*Spatial Ability	41.759	2	20.880	3.118	.048*
Treatment*Gender*Spatial Ability	14.410	2	7.205	1.076	.345
Error	716.429	107	6.696		
Total	43071.000	120			
Corrected Total	1220.325	119			

a. R Square = .431 (Adjusted R Square = .347)

According to Table 1, there was a significant main impact of the treatment on the hybridization achievement of the students ($F_{(1,119)=}36.83$; $p<0.05$;$\eta2=0.256$). As a result, the null hypothesis Ho1 was rejected, suggesting that the treatment affects students' hybridization performance. With a 25.6% effect size, the treatment was shown to have contributed to 25.6% of the overall changes in the variance of the students' post-test scores during the hybridization process.

Table 2
Estimated marginal means for post-achievement: Treatment

Dependent Variable: Post-Achievement

Treatment	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Computer animation	20.096[a]	.383	19.337	20.856
Control	16.885[a]	.365	16.161	17.608

a. The following values are used to assess covariates that occur in the model: Prior Performance = 10.13

According to Table 2, the primary reason for the main effect of treatment is the difference between the post-test mean scores of students exposed to computer animation (20.096) and those exposed to the traditional lecture approach (16.885).

Ho_2: There is no significant main effect of gender on students' achievement in hybridization

Table 1 shows that gender does not have a significant main impact [$F_{(1,119)}$= 0.078;p>0.05]. Hence, the null hypothesis was Ho2 is not rejected.

Ho_3: There is no significant main effect of spatial ability on learners' performance in the hybridization concept.

Table 1 shows that the achievement of learners in hybridization is not significantly impacted by spatial ability [$F_{(1,119)}$=0.039;p>0.05]. Therefore, Ho3, the null hypothesis, is accepted. This indicates that spatial ability does not affect learners' hybridization achievement.

Ho_4: There is no significant interaction effect of treatment and gender on students' achievement in hybridization concept

Table 1 shows that there is no significant interaction between treatment and gender [$F_{(1,119)}$=0.479;p>0.05] in terms of learners' hybridization achievement. As a result, Ho4, the null hypothesis, is accepted. This suggests that pupils' hybridization performance is unaffected by the interaction between treatment and gender.

Ho_5: There is no significant interaction effect of treatment and spatial ability on students' achievement in learning hybridization concept.

The interaction impact of spatial ability and treatment [$F_{(2,119)}$ =2.042;p>0.05] on learners' hybridization achievement is not significant, as shown in Table 1. Therefore, null hypothesis Ho5 was not rejected. This suggests that learners' achievement in hybridization is not affected by the interaction between treatment and spatial ability.

Ho_6: There is no significant interaction effect of gender and spatial ability on students' achievement in hybridization concept.

The interaction impact between gender and spatial ability [$F_{(2,119)}$=3.118;p<0.05; η2=0.055] on learners' hybridization achievement is shown to be significant in Table 4.1. As a result, Ho6, the null hypothesis, is rejected. This suggests that learners' achievement in hybridization is determined by the relationship between gender and spatial ability. The impact size of the interaction between gender and spatial ability is 5.5%. Table 4 of the estimated marginal means was generated to gain insight into the effect of interaction.

Table 3
Estimated marginal means of gender and spatial ability

2. Gender * Pre-Spatial Ability					
Dependent Variable: Post-Achievement					
				95% confidence Interval	
Gender	Spatial Ability	Mean	Std. Error	Lower Bound	Upper bound
Female	Low	17.531[a]	.877	15.794	19.269
	Medium	18.792[a]	.453	17.894	19.691
	High	19.368[a]	.582	18.215	20.521
Male	Low	19.302[a]	.595	18.123	20.481
	Medium	18.137[a]	.710	16.730	19.544
	High	17.811[a]	.591	16.639	18.983

a. Covariates appearing in the model are evaluated at the following values: Pre-Achievement= 10.13

According to Table 3, among the females, those with high spatial ability got the highest hybridization posttest mean score (19.368). Conversely, the male with low spatial ability had the highest hybridization posttest mean score (19.302). This suggests that high spatial ability is a benefit for achieving high hybridization scores among females. However, boys with low spatial ability scored more than those with medium and high spatial ability, meaning that high spatial ability may be a disadvantage for performing well in hybridization among boys.

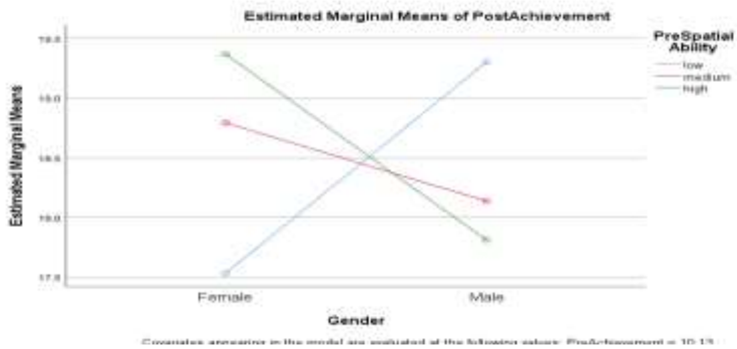

Figure 5
Gender and spatial ability have a disordinal interaction influence on students' hybridization achievement.

The figure indicated above illustrates the disordinal connection between gender and spatial ability on the performance of learners in hybridization.

Ho_7: There is no significant interaction effect of treatment, gender, and spatial ability on learners' performance in hybridization concept.

Table 1 shows that there is no significant interaction impact between treatment, gender, and spatial ability [$F(2,119)=1.076;p>0.05$] on learners' hybridization performance. This leads to the acceptance of the null hypothesis, Ho7. This shows that treatment, gender, and spatial ability do not interact significantly to determine how well learners do during hybridization.

DISCUSSION

The results of the study revealed the treatment has effect on learners' hybridization performance. The results demonstrated that the treatment (computer animation) significantly improved learners' hybridization performance as compared to the lecture method. Therefore, compared to learners exposed to traditional lecture techniques, learners exposed to computer animation scored higher on the hybridization achievement posttest. Computer animation was helpful in the meaningful learning of hybridization concepts based on these findings. This has expanded the list of abstract chemistry concepts that computer animation could improve students' achievement in them. The list known to literature includes Acid-Base reactions (Jack & Gamnjoh, 2020); and the mechanism of dissolution of salt in water (Falvo & Suits, 2009). The results of Anekwe & Opara (2021), who found learners who learned chemical bonding through animation performed better and retained the concept, and Egbutu & Okoli (2021), who believed that computer animation and inquiry methods had a significant impact on the interest of learners in chemistry, was also supported by Anggroaeni et al. (2022). Furthermore, compared to the verification method of education, the EIGER learning technique had a higher influence on students' conceptual and algorithmic grasp of stoichiometry. Even outside chemistry Hanif (2020) recommended that the interactive motion graphic video material created is workable and has been shown to improve the science learning achievements of primary school children in the fifth grade based on scientific principles of independence and student learning results. Simanjuntak et al. (2023) suggested that the use of blended learning with Edmodo support has a major impact. Additionally, virtual simulations may have a sizable and beneficial impact on students' physics performance, according to Antonio & Castro (2023), and Nsima et al. (2023) provide evidence of the significant influence computer animation techniques have on students' academic achievement in foundational science and technology courses.

Furthermore, the study's results demonstrated that students' performance in hybridization was not significantly impacted by their gender. This implies that the difference in the hybridization post-achievement according to gender is insignificant. Meaning that the gender of the student does not give them any superior advantage regarding achievement in hybridization. This is not in agreement with the findings of Falvo & Suits (2009) which revealed that gender has a main effect on students' achievement in understanding the mechanism of salt dissolution apart from the main effect of treatment in Falvo & Suits study, which is computer animation. Their study further stated that, the treatment and gender interaction had no significant influence on students' hybridization posttest achievement. The noticeable effect of this study is that computer animation improves students' learning of hybridization irrespective of gender. This implies that the gender of the students does not give them a superior advantage in terms of the gains that came about as a result of learning hybridization with computer animation. Either males or females can benefit from learning hybridization with computer animation. This supports Falvo & Suits's (2009) finding that animation is a real tool for bridging the gender gap in scientific education. The results support

Alexander's (2016) findings, which showed that there was no obvious difference in male and female learners' achievement in terms of the influence of computer simulation teaching approach on learning hybridisation. Gambari, Emmanuel, and Tobi (2014) found no obvious difference in boys' and girls' performance while utilising computer-based simulation to study physics. Also, the result support the finding of Otuturu (2022) who discovered that learners taught environmental topics in biology with a computer animation programme performed significantly different academically than male and female students. In contrast to the results of Jack & Gamnjoh (2020), who found that female students taught Acid-Base reactions through computer simulation achieved more than their male counterparts. In addition, Nwoye & Okeke (2023) found no evidence of a relationship between gender and teaching strategies and students' physics memory.

Furthermore, the study's conclusions demonstrated that spatial skill had no significant effect on students' academic performance. The study's findings suggest that students' performance on the hybridization posttest is not dependent on their spatial aptitude. Meaning that the level or category of students' spatial ability is not influencing their achievement in hybridization. The findings supported those of Falvo and Suits (2009), who discovered no significant association between students' performance in the salt dissolving procedure and spatial aptitude. It does, however, go counter to the findings of Thayban, Haris, Erga, La Alio, & Ahmad (2022), who discovered a favourable correlation between students' performance in comprehending molecular symmetry and their spatial skills. The findings also contradict Asuku, Hassan, and Gana's (2021) conclusion, which indicated a statistically significant association between learners' kinematic performance and their spatial skills. The results showed that there is no significant relationship between treatment and spatial ability on students' hybridization performance. The study's findings suggest that the interaction impact of treatment and spatial ability does not significantly determine students' hybridization performance. The findings of this study suggest that all learners, regardless of spatial ability, had higher post-achievement ratings. The study outcome can be attributed to the pedagogical usefulness of computer animation utilized for students in the experimental group. This study also revealed that the computer animation instructional package enhanced students' achievement irrespective of their spatial ability. The study findings disagree with the findings of Kingir & Geban (2013) that treatment and spatial ability had interaction impact on learners' performance. Specifically, Kingir & Geban found out that students with higher spatial ability in the computer-based learning environment had higher chemistry achievement scores than those with lower spatial ability in the CBLE group. On the other hand, computer animation instructional package improves students' achievement in hybridization irrespective of their spatial ability category in this study.

Furthermore, the results showed a significant gender and spatial ability interaction effect on students' hybridization performance. This suggests that pupils' performance in hybridization is influenced by the relationship between gender and spatial ability. Specifically, among female students, the highest hybridization posttest performance mean score was obtained by females with strong spatial ability, whereas the highest hybridization posttest performance mean score went to male students with low spatial ability. Thus, having a high spatial ability was an advantage among the female students with regard to their posttest hybridization achievement scores. Male pupils who struggled with spatial awareness, on the other hand, excelled. This study's most intriguing discovery is the disordinal characteristics of the gender-spatial ability interaction effect, which indicates that females with strong spatial ability acquire chemical concepts related to hybridization the best. In contrast, males with low spatial ability performed best. This leaves many questions, among them is why males with low spatial ability performed approximately the same as females with high spatial ability in hybridization. Maybe because of their exposure to animation, the boys with low spatial ability learnt more, making their performance nearly identical to that of the girls with strong spatial ability. The fact that boys with good spatial ability scored lowest is another finding that deviates from the literature trend. It may be deduced that while females with high spatial ability learn hybridization more easily than males with the same spatial ability., The results of this investigation are not in line with the wealth of literature demonstrating that the relationship between gender and spatial aptitude often benefits men (Tzuriel & Ezego, 2010; Yuan et al., 2019). The study's results are not in line with those of Lee and Kim (2016). They found that gender and spatial ability had a substantial interaction impact and that motivation and spatial ability were important predictors of chemical achievement. To be more specific, women with limited spatial ability scored lower than other groups, whereas men with good spatial ability scored higher in Lee and Kim's study.

Table 2 summarises the study's findings, which indicate that there is no statistically significant interaction effect of the relationship between treatment, gender, and spatial ability on the performance of students in hybridization. The findings showed that the performance of learners was not enhanced by the interaction of treatment, gender, and spatial ability. This result could be attributed to the importance and superiority of the computer animation instructional package adopted for this study. The package enhanced students' achievement irrespective of the student's gender and spatial ability.

CONCLUSIONS

The study's conclusions is that students' achievement in the hybridization concept is enhanced by the computer animation educational package. Improving students' achievement made the instructional package a valuable and effective learning tool. This study has established the instructional values of computer animation in teaching and learning irrespective of gender and spatial ability. Therefore, a computer animation instructional package is a powerful tool to improve students' learning performance in hybridization. Efficient use of the package will also improve the students' engagement and improvement in the teaching and learning process. In addition the interaction of gender and spatial ability favoured females with high spatial ability achievement in hybridization.

RECOMMENDATIONS

1. Computer animation instructional package is recommended to enhance students' achievement.
2. Given the positive outcomes experienced by females with superior spatial ability, efforts to enhance females' spatial ability are advised.

3. It is critical to look at why boys with high spatial abilities did poorly.

LIMITATIONS

The study's conclusions led to the following shortcomings being identified:

1. There was no assessment done to determine how computer literacy affected pupils' academic performance.
2. The impact of additional moderator factors on learners' achievement and perceived difficulty, such as parental support and psycho-social traits of the students, was not ascertained.

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