



Efficacy of Individualized and Collaborative Virtual Biology Instruction on Secondary School Students' Interest in Biology

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Abstract

This study investigated the efficacy of individualized and collaborative virtual biology instruction on secondary school student's interest in Biology. The study was guided by three research questions and three null hypotheses. Quasi experimental research design was adopted. The study was conducted in Obollo-Afor education zone of Enugu state. The population of the study comprised 2406 SS 2 Biology students in the zone. The sample size for the study comprised of 144 Biology students, from four intact SSS 2 classes, sampled through multistage sampling procedure. The instruments used for data collection are Biology Interest Inventory (BII) and Standardized Ability Test (SAT). The instruments were validated by two lecturers in Biology Education, one in measurement and evaluation unit, one senior secondary school Biology teacher and one academic staff from the Department of Computer Science. The reliability indices of the BII as determined using Cronbach Alpha respectively and they yielded internal consistency reliability index of 0.87. The experimental lasted six weeks and students were assigned to individualized and collaborative virtual Biology instruction groups. Data collected were analysed using SPSS version 25. Mean and standard deviation were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses. Results revealed a significant difference in the mean interest rating of Biology students taught with individualized and collaborative virtual biology instruction, in favour of students taught with collaborative virtual Biology instruction; the influence of cognitive ability level on interest of Biology students is not significant. Based on the findings, the study recommends among others that collaborative and individualized virtual Biology instruction be adopted by teachers to improve students learning outcomes in Biology, and teachers should monitor the interest of their students in Biology.

Keywords: Individualized Virtual Biology Instruction, Collaborative Virtual Biology Instruction, Interest, Biology, Cognitive Ability.

Introduction

The increasing integration of digital technologies into education has created new opportunities for improving teaching and learning in secondary schools. Beyond acquiring scientific knowledge, students are expected to develop curiosity, sustain interest and actively participate in learning activities. Biology, in particular, provides students with knowledge of living organisms, their structures, functions and interactions with the environment. However, the abstract nature of some biological concepts, extensive curriculum content and limited opportunities for practical activities can make learning challenging and reduce students' interest in the subject. Interest plays an important role in students' learning experiences because it

influences their attention, participation and willingness to persist when faced with difficult concepts. Renninger and Hidi (2020) explained that interest supports persistence, engagement and continued exploration of learning materials. Consequently, promoting students' interest in Biology remains an important concern in science education.

Interest in Biology refers to students' curiosity, enjoyment, attention and willingness to engage in learning activities related to the subject. It develops through students' interactions with learning materials, teachers, classmates and the learning environment. Interest may be situational, arising from particular learning activities, or

individual, developing into a relatively enduring preference for a subject (Renninger & Hidi, 2020). Students who develop interest in Biology are more likely to participate in classroom discussions, explore biological concepts and devote time to learning activities. Conversely, students with limited interest may demonstrate poor participation, reduced attention and little enthusiasm for learning. Renninger et al. (2019) found that learners do not respond identically to activities designed to stimulate interest, as their responses depend partly on the nature of the activity and their readiness to engage. Hidi and Renninger (2020) also explained that interest encourages information seeking and can support the continued development of knowledge. These findings highlight the importance of providing learning experiences that stimulate curiosity and sustain students' engagement with Biology.

The need to promote students' interest in Biology has encouraged researchers to explore instructional approaches that make learning more interactive and relevant. Traditional teacher-centred methods, which often emphasise explanations, note-taking and memorisation, may provide limited opportunities for students to explore biological concepts independently or interact with their peers. Although these methods can facilitate content delivery, they may not adequately address students' diverse learning needs or sustain their interest in challenging topics. The increasing availability of digital technologies has introduced alternative instructional approaches through which teachers can present biological concepts using animations, simulations, videos, virtual laboratories and interactive learning materials. These resources can make abstract biological processes more accessible and provide opportunities for students to explore concepts that are difficult to demonstrate in conventional classrooms. Ibe and Abamuche (2019) found that the use of audiovisual technological aids improved students' interest and achievement in secondary school Biology in Nigeria. Similarly, a systematic review by Situmorang et al. (2024) identified the potential of digital game-based learning to support interactive and engaging Biology instruction. These findings suggest that appropriately designed technology-supported instruction can provide learning experiences that stimulate students' interest in Biology.

Within technology-supported instruction, virtual Biology instruction provides opportunities for students to interact with digital learning resources through individual or group activities. Individualized virtual instruction allows students to

engage with learning materials independently, control their learning pace and revisit difficult concepts as necessary. This approach may promote interest by providing students with opportunities to explore biological concepts according to their individual needs and preferences. Students can repeat activities, examine visual representations and concentrate on topics they find particularly interesting without being restricted by the pace of other learners. Renninger and Hidi (2020) noted that supporting learners' interest requires recognising differences in their readiness to engage and providing opportunities for meaningful participation. Individualized virtual instruction may therefore help students maintain attention and develop interest through independent exploration. However, its effectiveness may depend on students' ability to regulate their learning, maintain concentration and engage meaningfully with the available resources.

Collaborative virtual Biology instruction, in contrast, involves students working together through digital platforms to achieve shared learning objectives. Students may participate in virtual discussions, group assignments, shared simulations and other interactive activities that require them to exchange ideas, explain concepts and solve problems collectively. This approach provides opportunities for learners to benefit from one another's knowledge and perspectives while developing a shared understanding of biological concepts. Onu et al. (2020) found that collaborative instructional strategies improved students' interest and achievement in Biology compared with conventional instruction. Similarly, research on collaborative problem-solving among secondary school Biology students in Benue State found that students exposed to collaborative problem-solving demonstrated significantly different interest ratings from those taught using discussion methods (Ede & Eka, n.d.). These findings provide evidence of the potential of collaborative learning to support students' interest in Biology. Virtual collaboration may extend these opportunities by enabling students to interact with digital learning materials and one another, discuss biological concepts and participate in shared learning activities.

The effectiveness of individualized and collaborative virtual instruction may differ because the two approaches provide distinct learning experiences. Individualized instruction gives students greater control over their learning pace and opportunities for independent exploration, whereas collaborative instruction emphasises interaction,

shared problem-solving and the exchange of ideas. While independent learning may allow students to concentrate on concepts they find difficult, collaboration may stimulate interest through peer interaction, discussion and shared discoveries. Renninger et al. (2019) found that learners' responses to activities intended to stimulate interest vary according to the nature of the activity and individual characteristics. This suggests that the organisation of virtual learning activities may influence students' interest in Biology. Individualized instruction may appeal to students who prefer independent exploration, while collaborative instruction may provide stimulating social interaction for those who benefit from working with others. However, these possible differences require empirical investigation rather than assumption.

Evidence supporting technology-supported and collaborative instruction in Biology has continued to emerge. Ibe and Abamuche (2019) found that secondary school students exposed to audiovisual technological aids demonstrated higher interest and achievement in Biology than students taught without these aids. Onu et al. (2020) also reported that collaborative instructional strategies improved students' interest and achievement in Biology. In addition, Situmorang et al. (2024), in a systematic review, identified the potential of digital game-based learning to support interactive Biology learning. These studies demonstrate the potential of technology-supported and collaborative approaches to improve students' learning experiences. However, they examined different instructional methods and did not directly compare individualized and collaborative virtual Biology instruction. Consequently, there is limited empirical evidence on how these two approaches influence students' interest, particularly when implemented in virtual learning environments and among secondary school students.

Within the Nigerian educational system, the integration of digital technologies into Biology instruction presents opportunities to provide students with more interactive and flexible learning experiences. However, the effectiveness of virtual instruction may depend on how learning activities are organised and whether students engage with the materials independently or collaboratively. Although Ibe and Abamuche (2019) established the potential of technology-supported instruction and Onu et al. (2020) demonstrated the value of collaborative learning, neither study directly investigated the comparative efficacy of

individualized and collaborative virtual Biology instruction. The available evidence therefore leaves questions about how these two modes of instruction influence students' interest in Biology, particularly among secondary school students in Enugu Education Zone. This makes it necessary to examine the two approaches within the same study.

Considering the importance of students' interest in Biology and the opportunities provided by digital technologies, there is a need for further empirical evidence on instructional approaches that can stimulate and sustain students' interest. Comparing individualized and collaborative virtual Biology instruction may provide useful information on how independent learning and peer interaction influence students' engagement with biological concepts. Such evidence could guide Biology teachers in selecting appropriate virtual instructional approaches and inform decisions on integrating digital technologies into secondary school teaching. Against this background, this study examined the efficacy of individualized and collaborative virtual Biology instruction on secondary school students' interest in Biology.

Research Questions

The following research questions were posed to guide the study;

1. What is the efficacy of individualized and collaborative virtual Biology instruction on students' mean interest rating in Biology?
2. What is the influence of cognitive ability levels on students' mean interest rating in Biology?
3. What is the interaction effect of modes of virtual Biology instruction and cognitive ability levels on students' interest in Biology?

Hypotheses

The following null hypotheses were formulated for the study and tested at a 0.05 level of significance.

- Ho₁: There is no significant difference in the mean interest rating of students taught Biology using individualized and collaborative virtual Biology instruction.
- Ho₂: The influence of cognitive ability levels on students' mean interest rating in Biology is not significant.
- Ho₃: There is no significant interaction effect of modes of virtual Biology instruction and cognitive ability levels on students' mean interest rating in Biology.

Methods

The study adopted quasi experimental research design, specifically the non-equivalent control group design. The study was conducted in Obollo-Afor education zone of Enugu state. The population of this study comprised of 2,406 Senior Secondary School 2 (SSS2) students studying Biology in 43 public co-educational secondary schools in Obollo-Afor Education Zone. This population comprises of 1038 male students and 1,757 female students. The sample size for the study consists of 144 (51 female and 93 males) senior secondary school two (SSS 2) Biology students, from four intact SSS 2 classes. Multistage sampling procedure used to select the secondary schools which were used for the study. First, simple random sampling technique (balloting without replacement) was used to select two LGAs out of the three LGAs in Obollo-Afor education zone. Then, purposive sampling technique was used to sample two senior secondary schools from each of the selected LGAs. The criteria for purposiveness include that the schools must have a functioning Biology laboratory, and have Biology teachers with adequate qualification for teaching Biology (a minimum of Nigerian Certificate in Education, NCE, in Biology). The schools must also possess a functional computer laboratory to allow the researcher host the instructional packages. Finally, one stream of SSS 2 class studying Biology, were then be selected from each of the four sampled schools, using simple random sampling technique. Two classes were then be assigned to the individualized virtual Biology

instruction group, and the remaining two were be assigned to the collaborative virtual Biology instruction group. The number of students in these four intact classes made up the sample for the study.

The instruments for data collection are Biology Interest Inventory (BII) and Standardized Ability Test (SAT). A treatment instrument called Virtual Biology Instruction (VBI) was also developed for the study and stimulus instruments (lesson plans were also used). The instruments were validated by three experts in the University of Nigeria Nsukka, and trial-tested on 20 SS2 students of Community Secondary School, Obukpa. The experimental procedure spanned 6 weeks, covering training of research assistants, administration of pretests, instructional phase where sampled student groups were taught using individualized and collaborative virtual biology instruction, and administration of post-tests. Measures were adopted to control the following extraneous variables: experimental bias, school variable, initial group difference, variability of instructional situation, teacher variable, subject interaction and effect of pre-test on post-test. The data collected from the study was analyzed using SPSS version 25. Mean and standard deviation was used to answer the research questions posed for the study because these statistics measure average value, coverage and spread of the data. Analysis of Covariance (ANCOVA) with pretest as covariate was used to test the hypotheses formulated for the study at 0.05 level of significance.

Results

Findings from this study are presented in tables in line with the research questions and corresponding hypotheses which guided the study.

Table 1: Mean interest rating and standard deviation of students exposed to individualized and collaborative virtual Biology instruction.

Group	Pre-Test			Post-Test		Adjusted Mean
	N	X	SD	X	SD	
Individualized	70	52.30	9.48	73.13	5.98	20.83
Collaborative	74	51.30	7.53	81.95	7.18	30.65

Results on Table 1 indicates that the interest of students exposed to collaborative virtual Biology instruction improved higher than those exposed to individualized virtual instruction. The post-test standard deviation scores of 5.98 and 7.18 for

students taught Biology using individualized and collaborative virtual instruction indicates that the mean interest rating of students with collaborative VBI varied more from their group mean than those of their counterparts taught with individualized VBI.

Table 2: Summary of Analysis of Covariance (ANCOVA) for the mean interest rating of students taught Biology using individualized and collaborative virtual Biology instruction.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3379.759	12	281.647	6.536	.000	.375
Intercept	18048.293	1	18048.293	418.868	.000	.762
Pre-Test	44.904	1	44.904	1.042	.309	.008
Treatment	1444.636	1	1444.636	33.527	.000	.204
Cognitive Ability	26.951	2	13.475	.313	.732	.005
Treatment * CA	216.183	2	108.092	2.509	.085	.037
Error	5644.567	131	43.088			
Total	877493.000	144				
Corrected Total	9024.326	143				

The result presented on Table 2 shows that there is a significant difference in the mean interest ratings of students taught Biology using individualized and collaborative virtual Biology instruction, $F(1,131) = 33.527$, $p = .000$, $\eta^2p = .204$. This is because the associated probability (sig) value of 0.000 is less than 0.05 level of significance the hypothesis was formulated. Hence, the null

hypothesis which stated that there is no significance difference in the mean interest rating of students taught with individualized and collaborative virtual Biology instruction is rejected. Moreover, the effect size difference ($\eta^2p = .204$) indicates that 20% variance exists between the mean interest scores of students taught using two modes of virtual Biology instruction.

Table 3: Mean interest rating and standard deviation of high, moderate and low cognitive ability student exposed to individualized and collaborative virtual Biology instruction.

Group	Pre-Test			Post-Test		Mean Gain
	N	X	SD	X	SD	
High	39	50.03	7.12	81.23	8.59	31.20
Moderate	81	52.83	9.34	76.70	7.29	23.87
Low	24	51.13	7.40	75.08	7.32	23.95

Results on Table 3 shows that cognitive ability level influenced the interest of students with those with higher cognitive ability having highest interest followed by low and then moderate. The post-test standard deviation scores of 8.59, 7.29, and 7.32 for students with high, moderate and low cognitive ability levels taught Biology using individualized virtual instruction indicates that the mean interest rating of students with high ability level varied more from their group mean than those of their counterparts.

The result presented on Table 2 shows that the influence of cognitive ability levels on students'

mean interest rating in Biology is not significant, $F(2,131) = .313$, $p = .732$, $\eta^2p = .005$. This is because the associated probability (sig) value of 0.732 is greater than 0.05 level of significance. Hence, the null hypothesis which stated that the influence of cognitive ability levels on students' mean interest rating in Biology is not significant is not rejected. Moreover, the effect size difference ($\eta^2p = .005$) indicates that 0.5% variance exists between the mean interest rating of students with high, moderate and low ability levels taught using two modes of virtual Biology instruction.

Table 4: Mean interest rating and standard deviation of students with high, moderate and low cognitive ability levels taught Biology using two modes of virtual Biology instruction.

Group	Pre-Test				Post-Test		Adjusted Mean
	CA	N	X	SD	X	SD	
Individualized Virtual Instruction	High	8	48.50	7.52	71.63	6.74	23.13
	Moderate	43	52.91	10.62	73.19	5.85	20.28
	Low	19	52.53	7.20	73.13	5.98	20.60
Collaborative Virtual Instruction	High	31	50.41	7.09	83.71	7.21	33.30
	Moderate	38	52.74	7.77	80.68	6.75	27.94
	Low	5	45.80	6.06	80.60	9.40	34.80

The results showed that students' interest in Biology improved across all cognitive ability levels following both individualised and collaborative virtual instruction. Under individualised instruction, students with high cognitive ability recorded the highest mean gain (23.13), followed by those with low (20.60) and moderate (20.28) cognitive ability. However, under collaborative instruction, students with low cognitive ability recorded the highest mean gain (34.80), followed by those with high (33.30) and moderate (27.94) cognitive ability. These results indicate that collaborative virtual instruction produced greater improvements in students' interest than individualised virtual instruction across all three cognitive ability levels.

The result presented on Table 2 shows that there is no significant interaction effect of modes of virtual Biology instruction and cognitive ability

levels on students' mean interest rating in Biology, $F(2,131) = 2.509$, $p = .085$, $\eta^2 p = .001$. This is because the associated probability (sig) value of 0.085 is greater than 0.05 level of significance. Hence, the null hypothesis which stated that there is no significant interaction effect of modes of virtual Biology instruction and cognitive ability levels on students' mean interest rating in Biology is not rejected. Moreover, the effect size difference ($\eta^2 p = .001$) indicates that 0.1% variance exists between the mean interest rating of students with high, moderate and low ability level taught Biology using two modes of virtual Biology instruction. The interaction graph below shows that cognitive ability levels (high, moderate and low) plots against teaching strategy for Biology students' interest ratings does not intercept, indicating that there is no significant interaction effect.

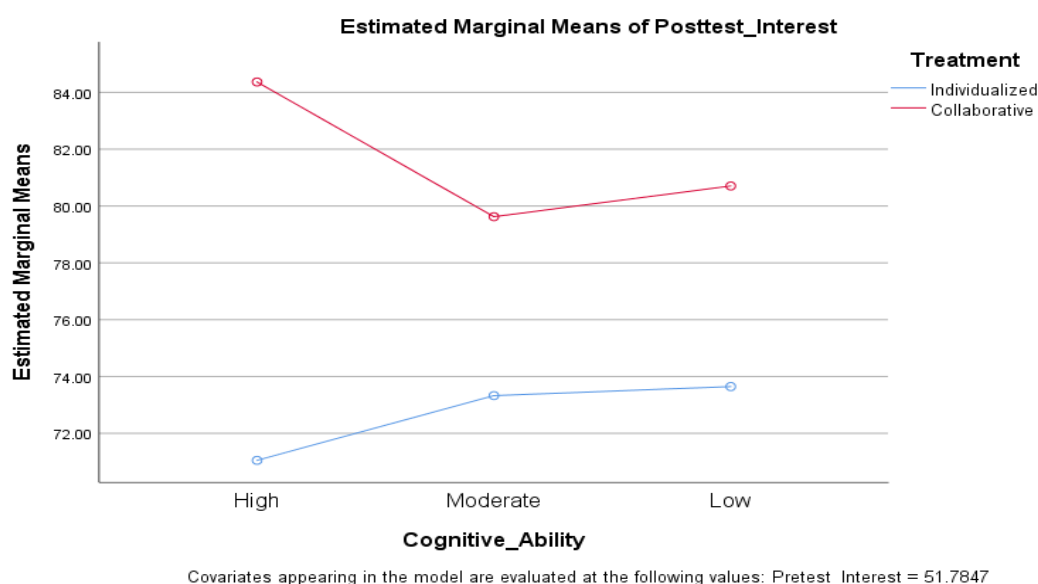


Figure 1: Graph showing the interaction effect for teaching strategies and cognitive ability on Biology students' interest rating.

Discussion of Findings

The findings revealed that students taught Biology through collaborative virtual instruction achieved higher mean interest ratings than those taught through individualised virtual instruction, with statistically significant differences between the groups. This suggests that collaborative virtual instruction may enhance students' interest and achievement by promoting peer interaction, active participation, knowledge sharing and immediate feedback. Through collaboration, students can discuss biological concepts, correct misconceptions and learn from one another, thereby creating an interactive learning environment that supports understanding and motivation. This interpretation is consistent with contemporary research on collaborative learning, which highlights the role of social interaction, active engagement and shared knowledge construction in improving students' learning outcomes. Recent evidence supports this finding. Driessen et al. (2024), in a meta-analysis of 91 studies, found that group work improved students' academic performance in Biology. Similarly, Akpen et al. (2024) reported that interactive online learning activities and meaningful interaction with teachers and peers could support student engagement and academic performance. These findings provide support for the present study, although the benefits of collaboration may depend on how virtual learning activities are organised.

The findings revealed that cognitive ability had no statistically significant influence on students' interest in Biology. Although students with high, moderate and low cognitive ability levels experienced improvements in interest following the instructional intervention, those with high cognitive ability recorded greater mean gains. This suggests that students' cognitive ability may be associated with differences in the extent to which their interest improves, even when the overall differences are not statistically significant. The findings also indicate that both collaborative and individualised virtual Biology instruction can promote students' interest, irrespective of their cognitive ability levels. This highlights the importance of providing varied instructional experiences that encourage active participation and accommodate differences in students' learning abilities. Recent research provides related evidence on the relationship between students' interest and learning experiences. Gustia and Suhartini (2021) found that students' interest in Biology was associated with their cognitive learning outcomes during online instruction. Similarly, Höffler et al. (2021) reported that students'

fascination with Biology was positively related to their learning and long-term knowledge retention. Although these studies did not directly examine differences in interest across cognitive ability levels, they highlight the importance of interest in Biology learning. The present finding adds to this evidence by showing that students with different cognitive ability levels can experience improvements in interest following virtual instruction, even though the differences between the ability groups were not statistically significant.

The findings revealed no significant interaction effect of teaching strategy and cognitive ability on students' interest in Biology. This indicates that the effects of collaborative and individualised virtual Biology instruction on students' interest did not differ significantly across cognitive ability levels. Although students may vary in their ability to process and understand information, both instructional approaches can support their interest in Biology. Collaborative virtual instruction may provide opportunities for students to exchange ideas, interact with peers and participate actively in learning activities, while individualised instruction allows students to engage with learning materials at their own pace. These findings suggest that students' interest in Biology can be supported through different modes of virtual instruction, irrespective of their cognitive ability. This finding is consistent with Onu et al. (2020), who reported that collaborative instructional strategies improved students' interest in Biology. Similarly, the study by Effects of Three Basic Dimensions of Instructional Quality on Students' Situational Interest in Sixth-Grade Biology Instruction (2018) found that classroom management, supportive learning environments and cognitive activation positively influenced students' situational interest. These findings suggest that instructional approaches that promote active participation and supportive learning environments can foster students' interest in Biology. However, the present study extends this evidence by showing that the relationship between instructional strategy and students' interest did not vary significantly across cognitive ability levels.

Conclusion

The study concluded that collaborative and individualised virtual Biology instruction improved students' interest in Biology, irrespective of their cognitive ability levels. Although students with high cognitive ability recorded greater mean gains in interest, the differences among students with high, moderate and low cognitive ability were not

statistically significant. Similarly, teaching strategy and cognitive ability had no significant interaction effect on students' interest. These findings suggest that both instructional approaches can support the development of students' interest in Biology across different cognitive ability levels.

Recommendations

The following recommendations are made based on the findings of the study:

1. Biology teachers should adopt collaborative virtual instruction to promote students' interest in Biology. This approach should encourage peer interaction, group discussions, knowledge sharing and active participation in learning activities.
2. Biology teachers should use both collaborative and individualised virtual instruction to accommodate students with different cognitive ability levels. The choice of instructional approach should consider lesson objectives, available resources and students' learning needs.
3. Biology teachers should provide opportunities for students of different cognitive ability levels to participate actively in virtual Biology lessons. Group activities should be structured to encourage the contributions of students with high, moderate and low cognitive ability.
4. School administrators should provide adequate ICT facilities and reliable internet access to support the effective implementation of virtual Biology instruction. Teachers should also receive training on how to design and manage collaborative and individualised virtual learning activities.
5. The Ministry of Education and relevant curriculum planners should encourage the integration of collaborative and individualised virtual instruction into Biology teaching. Appropriate guidelines and instructional materials should be developed to help teachers use these approaches to improve students' interest, irrespective of their cognitive ability levels

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