Interdisciplinary Journal of Educational Practice
ISSN: 2837-1534 | Impact Factor: 7.24
Volume. 12, Number 3; July- September, 2025;
Published By: Scientific and Academic Development Institute (SADI)
8933 Willis Ave Los Angeles, California
https://sadijournals.org/index.php/IJEP |editorial@sadijournals.org

ENHANCING VIRUS EDUCATION IN BIOLOGY IN SECONDARY SCHOOLS THROUGH INNOVATIVE PEDAGOGIES: ADDRESSING MISCONCEPTIONS AND IMPROVING STUDENT ACHIEVEMENT AND RETENTION

Dr. Aje Foluke Opeyemi, Prof. Bello Ganiyu and Dr. Sulaiman Musa Mohammed
Department of Science Education Faculty of Education, University of Ilorin
Email: floopworld@gmail.com, bello.g@unilorin.edu.ng, sulaiman.mm@unilorin.edu.ng
DOI: https://doi.org/10.5281/zenodo.17120409

Abstract: This study investigated the impact of game-based learning (GBL) on the engagement, academic achievement, and retention of secondary school students in biology, with a specific focus on the topic of viruses, a concept often perceived as abstract and difficult to master. Conventional teaching methods fail to stimulate sustained interest or deep understanding in biology classrooms, particularly regarding virus-related content. In response, the Virus Card Game was introduced as an interactive tool to promote conceptual clarity and improve learning outcomes. A quasi-experimental, non-randomized pretest and post-test design was employed involving three instructional groups: GBL only, a blended approach combining GBL with conventional instruction, and conventional instruction only. Data were collected using standardized instruments, including the Student Virus Engagement Scale and the Virus Achievement Test. Observational checklists and a delayed post-test were also used to assess engagement and retention.

The findings revealed that students who were taught using GBL, especially those in the blended instruction group, exhibited significantly higher levels of engagement, achievement, and retention than their peers who were taught using conventional methods. Notably, no significant gender differences or interaction effects were found, the broad applicability of GBL across student demographics. These results underscore GBL's effectiveness as a pedagogical tool in biology education. Integrating games into conventional instruction fosters deeper engagement and enhances learning outcomes, particularly in complex scientific topics. This study advocates for the inclusion of GBL strategies in secondary science curricula and teacher training programs to support active learning, conceptual understanding, and inclusive science education.

Keywords: Game-Based Learning, Engagement, Achievement, Retention, Virus Concepts

Introduction

Biology is a fundamental science subject that contributes significantly to processes, health, and the environment. As Joshi et al. (2023) highlighted, biology encompasses the study of living organisms and their vital processes, which are essential for fostering scientific literacy and health-consciousness. Despite its relevance, poor performance is still a major concern. Students' misunderstanding and inability to properly interpret and answer

the questions by confusing "describe" with "explain" or "compare" with "contrast" affects overall achievement. Biology education often faces pedagogical challenges (Ogundare, et al., 2024), especially in the teaching of abstract topics such as viruses. Students frequently struggle with concepts related to virus structure, function, and transmission, resulting in limited engagement and poor academic performance.

Conventional lecture-based strategies often fail to adequately engage students or sustain their interest, especially when dealing with complex, abstract scientific content that results in shallow knowledge of the subject matter. In teaching biology, there is a need to employ a more innovative strategy (Ogundare et. al. 2024), such as edutainment, whose content entertains and educates simultaneously. Game-based learning (GBL) is a type of edutainment that has emerged as a promising pedagogical innovation that promotes student-centered, interactive, and experiential learning environments. GBL enhances motivation and encourages deeper cognitive involvement by integrating elements of play, competition, and problem solving (Hwang et al., 2023). This study explores how GBL, specifically through a tailored Virus Card Game, can address misconceptions and conceptual challenges associated with virus education among secondary school students in Ilorin, Nigeria.

Statement of the problem

The teaching and learning of virus concepts in biology remains challenging due to the abstract nature of these concepts and the limitations of conventional instructional methods. Students often demonstrate weak content retention even when some understanding is present through inaccurate definitions and consistent spelling errors of technical terms. Understanding biology is essential for addressing real-world issues, from preventing or managing diseases and conserving biodiversity to improving agricultural productivity. The COVID-19 pandemic highlighted the importance of viral literacy, yet studies (Isah et al., 2020; Mishra & Tripathi, 2021) have reported persistent misconceptions regarding virus transmission, structure, reproduction, and treatment among students. These gaps are worsened by a lack of student engagement and ineffective teaching strategies. GBL offers a potential solution by transforming passive learning environments into interactive, engaging, and student-driven experiences. Despite its promise, few studies in Nigeria have rigorously examined the effectiveness of GBL on learning virus-related content. This study addresses this gap by evaluating how GBL impacts the engagement, achievement, and retention of biology students in virus concepts.

Purpose of the study

The primary aim of this study was to investigate the effectiveness of GBL in enhancing the learning outcomes of secondary school biology students, particularly regarding the topic of viruses. The specific objectives were as follows:

(i) Assess the engagement levels of biology students when taught using GBL only, conventional strategies only, or a combination of both.

(ii) Evaluate biology student engagement across the three instructional methods.

(iii) Determine the achievement levels of biology students exposed to different teaching strategies.

(iv) The retention of virus concepts among biology students across the instructional groups was compared.

Theoretical Framework and Literature Review

This study is grounded in CLT, which emphasizes active knowledge construction through experiential and meaningful interactions. GBL aligns with this theory by offering immersive learning experiences that promote hands-on participation, problem-solving, and immediate feedback. Additionally, the self-determination theory (Ryan & Deci, 2020) underlines the importance of intrinsic motivation that is fostered through autonomy, competence, and relatedness, which GBL effectively nurtures.

Recent literature supports the use of GBL to enhance science education learning. Yildirim and Sen (2021) found that gamified science instruction significantly improved the emotional and cognitive engagement of students. Similarly, Adegbija and Fakomologbon (2022) reported enhanced participation and enthusiasm among Nigerian students of biology exposed to game-based activities. Despite these findings, most prior studies have not addressed how GBL specifically affects the learning of virus-related content or examined potential gender differences. This study fills that gap by focusing on both content-specific and demographic dimensions.

Methodology

A quasi-experimental, pretest, post-test control group factorial design was adopted, involving three instructional groups: Group I (GBL only), Group II (GBL + conventional), and Group III (conventional only). This study used a 3x2 factorial design to assess the main and interaction effects of instructional strategy and gender.

The population comprised all SSSI Biology students in Ilorin, Nigeria, because virus is taught at this level as one of the subtopics under micro-organisms. A multistage sampling technique was used to select three local government areas, from which three coeducational schools were purposively selected. The selection of the three schools was based on the presence of mixed gender schools, science laboratories where the students can play the game without exposure to harm, and qualified teachers across these schools to ensure that the study can assess the impact of GBL on students' understanding of virus concepts without the confounding variable of teacher qualification. Each school contributed one intact class to the study, totalling three classes.

Instruments and data collection

This study used both stimulus and response instruments. The stimulus instrument included the Virus Card Game, which was designed to interactively teach virus concepts. Response instruments included the Student Virus Engagement Scale (SVES) and the Virus Achievement Test (VAT) administered to students to gather data on prior knowledge on viruses and the post-test afterwards to gather data on achievement.

In addition, the trained research assistants used observation checklists to rate the engagement of students during instruction. A retention test using reshuffled VAT items administered two weeks after the post-test measured long-term learning.

Results

Quantitative analyses using ANCOVA and t-tests yielded the following key findings:

Students taught using GBL (only or combined with conventional instruction) outperformed those in the conventional group across all variables.

Engagement: Significantly greater in the GBL and blended groups ($F(2, 214) = 60.452$, $p < 0.05$).

Table 1

Descriptive statistics of biology students' engagement when taught virus concepts using game-based learning only, conventional strategy only, and game-based learning and conventional strategy combination

Engagement		Game-based Learning			Conventional Strategy			Game-based+Conventional		
		Mean	S.D.	Remark	Mean	S.D.	Remark	Mean	S.D.	Remark
Behavioral Engagement	Before	2.89	.76	Fair	2.79	.87	Fair	2.59	1.03	Fair
	During		.49	High	3.24	.52	Fair	3.68	.74	High

		3.62								
Cognitive Engagement	Before	2.39	.84	Low	2.43	1.18	Low	2.37	.88	Low
	During	3.58	.52	High	2.86	.78	Fair	3.71	.61	High
Emotional Engagement	Before	2.41	.87	Low	2.38	1.09	Low	2.28	1.14	Low
	During	3.55	.61	High	3.11	.69	Fair	3.77	.72	High
Social Engagement	Before	2.87	.73	Fair	2.68	.95	Fair	2.77	1.10	Fair
	During	3.39	.62	Fair	3.01	.57	Fair	3.32	.97	Fair
Grand Mean	**Before**	**2.64**		**Fair**	**2.57**		**Fair**	**2.50**		**Fair**
	During	**3.54**		**High**	**3.09**		**Fair**	**3.62**		**High**

Engagement: Biology students were most engaged in the blended group, followed by the GBL-only group ($F_{(2, 214)} = 60.452$, $p<0.05$).

Table 2:

Analysis of covariance showing the difference in the engagement of biology students when taught virus concepts using game-based learning, conventional strategy, and the combination of game-based learning and conventional strategy

Source	Type III sum of squares	of	Mean Square	F	Sig.
Corrected Model	2143.916[a]	3	714.639	40.595	.000
Intercept	5781.312	1	5781.312	328.406	.000
Before Treatment	.064	1	.064	.004	.952
Groups	2128.405	2	1064.203	60.452	.000
Error	3767.295	214	17.604		
Total	219396.000	218			
Corrected Total	5911.211	217			

a. R Squared = .363 (adjusted R Squared = .354)

Achievement: The blended group had the highest achievement, followed by the GBL-only group ($F(2, 214) = 99.194$, $p < 0.05$).

Table 3

Descriptive statistics of achievement of biology students when taught virus concepts using game-based learning only, conventional strategy only, and game-based learning and conventional strategy combination

Groups		Min	Max	Mean	S.D.	Remark
Experimental Group I (Game-based learning only)	Pre-test	6.0	12.0	10.17	3.18	Average
	Post-test	9.0	17.0	14.69	2.33	High
Experimental Group II (Game-based learning and conventional)	Pre-test	5.0	11.0	8.98	3.42	low
	Post-test	11.0	19.0	16.43	2.91	Very High
Control Group (Conventional strategy)	Pre-test	6.0	12.0	9.12	2.93	Low
	Post-test	7.0	15.0	11.65	3.71	Average

Retention: The blended group retained the most, followed by the GBL-only group with the conventional group having the lowest retention ($F(2, 215) = 2.132$, $p < 0.05$).

Table 4:

Descriptive statistics of student retention when taught a virus concept using game-based learning, conventional strategy, and a combination of game-based learning and conventional strategy

			Retentive			
Groups	**Min**	**Max**	**Mean**	**Post-test**	**%**	**Remark**
Game-based only	9.0	16.0	12.71	14.69	87%	Very High
Conventional strategy only	8.0	13.0	8.53	11.65	73%	High
Game-based and conventional	11.0	18.0	14.86	16.43	90%	Very High

Gender and interaction effects on engagement and achievement: No significant interaction effects were observed between gender and instructional strategy across any variable.

Table 5:

Analysis of covariance showing the interaction effects of game-based learning and gender on the engagement of biology students in virus concepts in Ilorin, Nigeria

Source	Type III sum of squares	of	Mean Square	F	Sig.
Corrected Model	29.079[a]	2	14.540	1.161	.320
Intercept	1606.703	1	1606.703	128.277	.000
Before Treatment	27.498	1	27.498	2.195	.143
Gender	.856	1	.856	.068	.795
Error	814.141	65	12.525		
Total	69011.000	68			
Corrected Total	843.221	67			

a. R Squared = .034 (adjusted R Squared = .005)

Table 6:

Analysis of covariance showing the interaction effects of game-based learning and gender on the achievement of biology students in virus concepts in Ilorin, Nigeria

Source	Type III sum of squares	Df	Mean Square	F	Sig.
Corrected Model	13.317[a]	2	6.659	1.103	.338
Intercept	589.640	1	589.640	97.660	.000
Pretest	13.053	1	13.053	2.162	.146
Gender	.711	1	.711	.118	.733
Error	392.447	65	6.038		
Total	12002.000	68			
Corrected Total	405.765	67			

a. R Squared = .033 (adjusted R Squared = .003)

Discussion

The findings of this study revealed that biology students who were taught the topic virus using a combination of game-based learning (GBL) and conventional strategies, as well as those who were taught using GBL only, demonstrated higher engagement and achievement compared to those who were taught using conventional strategies only. The findings affirm the benefits of blending GBL with conventional teaching strategies in science education and the potential of GBL as a powerful instructional strategy in secondary science education. Another finding of this study showed that no statistically significant interaction effects existed between game-based learning and gender on biology students' engagement, achievement, and retention. Students exposed to GBL demonstrated greater interest, deeper engagement, improved academic performance, and longer retention of virus concepts. The lack of gender disparity that GBL can promote equity and inclusivity in science classrooms.

Conclusion

Game-Based Learning (GBL) significantly enhances student engagement, achievement, and retention when integrated with conventional instructional strategies. The study also concluded that gender did not have a statistically significant influence on students' engagement, achievement, or retention when they were exposed to game-based learning strategies, whether independently or in combination, but it did foster a gender-inclusive learning environment. These benefits are especially critical when teaching complex and abstract topics, such as viruses. Given the urgent need for scientifically literate citizens, especially in the post-pandemic era, GBL is a viable and scalable approach to transforming biology education.

Recommendations

GBL should be integrated into the biology curricula of secondary schools to foster active, student-centered learning.

Teacher training programs should include modules on designing and implementing instructional strategies, such as educational games.

Schools and policymakers should institutionalize game-based strategies for difficult and abstract science topics.

Further research should explore the long-term impact of GBL on science attitudes and career aspirations of students.

References

Adegbija, M. V., & Fakomogbon, M. A. (2022). Influence of educational games on the retention of biology students in Nigeria Journal of Educational Technology and Curriculum Development, 8(1), 60–72.

Hwang, G. J., Chiu, M. C., Hsia, L. H., & Chu, H. C. (2023). Promoting art appreciation performances and behaviors in an effective and joyful context: A two-tier test-based digital gaming approach Computers and Education, 194, 104706

Isah, M. B., Abdulsalam, M., Bello, A., Ibrahim, M. I., Usman, A., Nasir, A., & Nass, S. S. (2020). Coronavirus Disease 2019 (COVID-19): Knowledge, attitudes, practices (KAP) and misconceptions in the general population of Katsina State, Nigeria. MedRxiv, 2020-06. https://doi.org/10.1016/j.medrxiv.2020.06.013.

Joshi, P., Kasar, C. R., Awate, P. J., & Sreedevi, V. (2024). Fundamentals of Cell Biology, Genetics, Molecular Biology, Evolution, and Ecology Academic Guru Publishing House.

Joshi, S., Heyner, E. R., & Rogers, K. (2023). Biology. Encyclopedia Britannica. Available from: https://www.britannica.com/science/biology

Mishra, S. K., & Tripathi, T. (2021). One year update on the COVID-19 pandemic: Where are we now? Acta Trop. 214, 105778.

Ogundare, A. A., Ahmad, M. A., Ambode, A. B., Olayinka, F. O., Babalola, F. E. & Usman, A. A. (2024). Technological, pedagogical and content knowledge of the preservice science teachers in kwara state: A need for paradigm Shift in teacher education in Nigeria. PLASU Journal of Library, Archival & Information Science, 1(2), 50-62.

Ogundare, A. A., Koledafe, O. S., Bello, G., Adeoye, G. A. (2024). Design and Development of a Rule-Based AI Tutoring System for Remediating Misconceptions in Secondary School Biology. Kashere Journal of Science and Education, 2(2), 27-38.

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions Contemporary Educational Psychology. https://doi.org/10.1016/j.cedpsych.2020.101860

Yıldırım, İ., & Şen, S. (2021). Effects of gamification on academic achievement: A meta-analysis study Interactive Learning Environments, 29(8), 1301-1318.