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Perceived Digital Game Instructional Strategies and Self-Regulated Learning as Predictors of Biology Students' Academic Engagement in Awka South LGA

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Abstract: Traditional biology instruction in secondary schools often relies on conventional teaching methods that struggle to sustain student attention, leading to declining interest and low academic engagement with complex biological concepts. This ongoing pedagogical challenge requires investigating innovative, student-centered predictors that can enhance classroom participation and active learning. The purpose of this study was to assess perceived digital game instructional strategies as well as goal setting self-regulated learning as predictors of academic engagement among biology students, Awka South Local Government Area. For this investigation, a correlational research design was chosen. The population of the study was all the senior secondary school biology students in the educational zone with a sample of one hundred and ten students obtained by convenient sampling technique. The three rating instruments adapted on a four point scale were used for data collection. High reliability indices were obtained with the Cronbach alpha method for the internal consistency of the items. Analyses of the collected data involved linear and multiple hierarchical regression analysis procedures at 5% significance level. The results showed that perceived digital game instructional strategies significantly predicted the academic engagement scores of the biology students when moderated by school type, accounting for more than two-thirds of the variance. In the same way, goal setting self regulated learning was significant predictors of academic engagement in terms of genders. Finally, the joint predictive model showed that the combination of digital game strategies and SRL explained 61.8% of the total variance in academic engagement. It is concluded that a pedagogical path towards maximizing student engagement is offered when modern technological framework is combined with structured self regulation habits.

Keyword : Academic engagement, Biology students, Digital game strategies, Goal setting, Self regulated learning

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Introduction

The learning of biology often presents abstract and complex biological pathways, molecular structures, and ecological systems that require students to do considerable cognitive processing. Traditional pedagogies based on lectures are found

not to be very effective in keeping learners engaged, thus researchers have explored a range of multifaceted predictors of academic engagement. Of these, perceived digital game instructional strategies and students' self-regulated learning were found to be important factors affecting classroom involvement (Akanni, 2026). The interplay between these pedagogical designs and psychological processes of the learners requires a deeper investigation because it can give empirical evidence to the science education of the present day.

The perceived digital game instructional strategies are emerging as a new external factor influencing students' engagement. Digital game-based learning embraces and applies dynamic elements to non-game scenarios, including immersive story narratives, virtual rewards, real-time feedback, and scaffolding challenges to make learning interactive. In biology education, the use of a virtual simulation enables students to interact again and again with basic biological micro-systems, which then becomes a visual process instead of an abstract conceptual framework (Situmorang et al., 2024). The game elements create a sense of self-determination and immediate feedback to the student. This design is supportive because it helps to reduce and manage academic anxiety that is linked to challenging science subjects, and directly increases students' participation in classrooms (Ratinho & Martins, 2023). The use of structured digital game architectures in instructional environments shifts the learning process from a straightforward transmission of facts to an active, exploratory learning process. Digital game-based activities have been shown to have a more positive effect on student engagement and motivation than traditional online activities, providing a good boost for the classroom and fostering active learning (Nadeem et al., 2023).

Self-regulated learning is the key inner learning system that propels and deepens students' involvement in learning, while digital game strategies are the required environment infrastructure that supports students' learning. Self-regulated learning is the characteristic of a learner who is able to actively plan, monitor, and reflect on his cognition in learning knowledge. Highly developed metacognitive self-regulation strategies are results of systematic improvements for students to cope with the demanding nature of scientific inquiry and complex concept comprehension. The research indicates that the external gamification elements most effectively align with the phases of SRL: when planning, goal-setting features are most beneficial and when monitoring, progress visualization features are most beneficial (Shao, 2026). In high-fidelity learning contexts, students are required to continually assess what they know about subjects such as cellular metabolism or genetics. Students' internal SRL habits limit distracting play elements within digital tools, ensuring that the game purposefully achieves the education goals. Highly self-regulated learners are able to test out hypotheses, analyse and reflect on their mistakes in the structured, gamified

context and actively adjust their study strategies, thus developing deep cognitive engagement.

A powerful system for predicting student engagement in biology is formed by the synergistic interaction of the digital instructional features with internal self-regulation. Academic involvement is a multi-faceted phenomenon that involves behavioural commitment, emotional involvement and cognitive commitment. Combining external digital tools such as computer animation and gamification with internal metacognitive habits guarantees that all three dimensions are addressed (Ruiz et al., 2024). Digital strategies engage behavioral and emotional interests and sustain cognitive investment for mastery over time through SRL. The use of adaptive education tools, Artificial Intelligence (AI), and service-learning can maximize science learning outcomes and avert student alienation (Ofozoba et al., 2024; Ofozoba et al., 2025; Anakpua et al., 2025).

The need to immediately intervene empirically in the drop in academic performance and engagement rate of biology students in Awka south is evident. Traditional, teacher centered approach that prevails in Anambra State classrooms is unable to communicate abstract concepts effectively. A fundamental gap in basic information exists about how interactive gamification works in resource-limited Nigerian public schools (NPSs) (Situmorang et al., 2024; Okelue et al., 2025). The regional literature tends to be very specific on infrastructural problems or to be very general about the curriculum problems (Worgu & Ikuru, 2026). The need to look into innovative tools such as computer animation, virtual classrooms, and self-regulatory skills to revitalise local classrooms thus has become an urgent educational priority (Nnalue et al., 2023, 2024; Christian-Ike et al., 2024, 2025a; Rita & Henrieta, 2025). Moreover, knowing how various students' factors such as gender, school location, science process skills, and external parents' attitudes affect the students' performance is significant to building effective predicting models (Christian-Ike et al., 2025b; Obikezie et al., 2025; Chukwunazo et al., 2025). This study is vital in filling these gaps in context to offer secondary school administrators with science-specific actionable instructional strategies that can be implemented to enhance science outcomes and turn around the trend of student disengagement in secondary schools in Awka South, using data.

Research Questions

1. How do perceived digital game instructional strategies predict the academic engagement of secondary school biology students in Awka South LGA based on their school type?
2. How does goal-setting self-regulated learning predict the academic engagement levels of secondary school biology students in Awka South LGA based on their gender?

3. How does perceived digital game instructional strategies and goal-setting self-regulated learning jointly predict the academic engagement levels of secondary school biology students in Awka South LGA

Research Hypotheses

1. HO1: Perceived digital game instructional strategies do not significantly predict the academic engagement scores of secondary school biology students in Awka South LGA when moderated by school type.
2. HO2: Goal-setting self-regulated learning does not significantly predict the academic engagement scores of secondary school biology students in Awka South LGA across gender categories.
3. HO3: Perceived digital game instructional strategies and goal-setting self-regulated learning does not jointly significantly predict the academic engagement levels of secondary school biology students in Awka South LGA

Methodology

The study employed the correlational research design to examine the perceived digital game instructional strategies and SRL as predictors of academic engagement of Biology students in Awka South Local Government Area. This design was considered suitable, because the researcher could investigate the direction and strength of the relationship between the variables as they occurred in nature and not be manipulated by the researcher. The study population consisted of all the senior secondary school Biology students in the educational zone, both in public and private schools. A convenient sampling technique was employed to select a sample of one hundred and ten biology students in an area. The empirical data for the predictive models was obtained from the following sample group who were the primary group from whom data was collected.

Three structured rating instruments were used for data collection, which were adapted for the participants: Perceived Usefulness of Digital Game Strategies Questionnaire, Goal Setting Self Regulated Learning Scale, and Academic Engagement Level in Biology Index. The instruments were designed in a four-point response scale that reflects students' attitude and participation in the process. The copies of the tools were given to experts in measurement and evaluation as well as lecturers in educational psychology for face and content validation so as to ensure that the tools measure the intended constructs effectively. All suggestions and changes made by the validators were incorporated in the final revision of the instruments. The internal consistencies of the items were computed using the Cronbach alpha method; the reliability coefficients were high (0.88, 0.79, and 0.81) indicating good scale stability and reliability in the field.

This was done by the researcher himself/herself with support from trained research assistants who visited the sampled secondary schools. Prior to interacting with the students, formal permission was obtained from concerned school authorities and biology teachers. The students who responded were briefed about the purpose of the study and explained them about how to fill the items properly and assured that the profiles will be kept confidential. The instruments were retrieved as soon as they were completed, to maximize the return.

The information from the one hundred and ten biology students were coded and then inputted into statistical software for quantitative analysis. The research hypotheses were tested at 5% significance level using linear regression analysis procedures. More specifically, variance diagnostics, coefficient determinations, and collinearity statistics were calculated to assess the strength of both the independent measures and the student engagement measures to predict the variance. Residual histograms were also created to ensure complete normality assumptions for the final decisions made in the parametric statistics.

Result and Discussion

Results

Table 1. Distribution of Respondents by Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	45	40.9	40.9	40.9
	Female	65	59.1	59.1	100.0
	Total	110	100.0	100.0	

The gender distribution of the 110 students sampled from the biology class is shown in Table 1. The female students are the main research participants accounting 59.1% (frequency 65) of the sample. On the other hand, boys make up 40.9% of the population, which is 45. This means that there are more females present in the study area.

Table 2. Distribution of Respondents by School Type

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Public	42	38.2	38.2	38.2
	Private	41	37.3	37.3	75.5
	Mission-owned	27	24.5	24.5	100.0
	Total	110	100.0	100.0	

Table 2 shows how the 110 students (biology) participating in the study were distributed institutionally. The Public schools have the largest share with 42 participants (38.2%) followed closely by the Private schools with 41 participants

(37.3%). The remaining 24.5% (27 students) attend a mission school. This representation shows that all major school management systems were represented in the data collection.

Table 3. Descriptive Statistics on the Perceived Usefulness of Digital Game Strategies

	N	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Playing educational biology games makes abstract concepts easier to understand.	110	3.35	.612	.375	-.362	.230	-.640	.457
Using digital biology quiz games makes learning science topics exciting for me.	110	3.25	.732	.536	-.420	.230	-1.030	.457
Computer-based educational games help me remember biology definitions much faster.	110	3.23	.553	.306	.055	.230	-.234	.457
I am more motivated to study biology when digital or mobile learning games are introduced.	110	3.14	.670	.449	-.165	.230	-.759	.457
Digital game-based learning helps me pinpoint the topics I need to study more.	110	3.05	.962	.925	-.786	.230	-.302	.457
Valid N (listwise)	110							

Table 3 shows descriptive statistics for the digital game strategies that were evaluated from the perspective of usefulness across 110 biology students. The average scores of all items were above 2.50 signifying high student agreement. The highest scores were obtained for making abstract concepts easier with the lowest scores scored for identifying the needs for studying (Mean = 3.05). All the items have negative skewness scores indicating that responses tend to be at the higher range of agreement.

Table 4. Descriptive Statistics on Goal-Setting Self-Regulated Learning

	N	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
I set specific learning targets for myself before starting a new biology topic.	110	2.59	1.199	1.437	-.267	.230	-1.478	.457
I allocate specific daily or weekly hours for reading my biology textbook and notes.	110	2.69	1.225	1.500	-.362	.230	-1.467	.457
I outline the key objectives I want to achieve before preparing for biology exams.	110	3.38	.620	.385	-.477	.230	-.627	.457
I evaluate my personal understanding of a biology topic after reading it.	110	2.88	1.081	1.169	-.692	.230	-.773	.457
I strictly follow my personal study timetable for biology revision.	110	3.07	1.163	1.352	-.928	.230	-.685	.457
Valid N (listwise)	110							

The goal-setting self-regulated learning indicators are included in the respondents' descriptive metrics in Table 4. The results show the overall compliance of self-regulation practices with the criterion, with all the items monitored achieving a score above the criterion of 2.50. Establishing key objectives prior to examinations received the highest baseline level of agreement (Mean = 3.38) and establishing initial targets before beginning a topic received the lowest baseline level of agreement (Mean = 2.59). The negative skewness of the distributions of the students' responses in the uniform column confirms a structural grouping of the answers towards the yes responses.

Table 5. Descriptive Statistics on Academic Engagement Level in Biology

	N	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
I pay close attention throughout the entire duration of my biology lessons.	110	3.52	.631	.399	-.960	.230	-.117	.457
I actively contribute to group discussions and ask questions during biology classes.	110	3.02	1.204	1.449	-.550	.230	-1.436	.457
I put maximum effort into completing all my biology classroom and take-home assignments.	110	3.62	.620	.385	-1.401	.230	.857	.457
I look forward to participating in biology practical sessions and lab experiments.	110	2.70	1.358	1.845	-.332	.230	-1.733	.457
I rarely get distracted or bored when biology topics are being explained in class.	110	3.35	.615	.378	-.390	.230	-.641	.457
Valid N (listwise)	110							

The descriptive statistics of students' academic engagement level in biology are shown in Table 5. Empirical results show that the overall engagement levels are high, with the average scores for all the five parameters being above the mid-point of 2.50. Making every effort to finish assignments was the item that got the highest agreement (Mean = 3.62), which was followed closely by being able to concentrate during lessons (Mean = 3.52). The lowest mean score (Mean = 2.70) and highest variance (Variance = 1.845) was recorded for anticipating lab sessions, indicating that there could be

different preferences for lab work among students. A negative skewness shows that, in general, respondents tended to agree more with the positive options of the items.

Research Hypothesis 1: Perceived digital game instructional strategies do not significantly predict the academic engagement scores of secondary school biology students in Awka South LGA when moderated by school type.

Table 6. Hierarchical Regression Model Summary for Predictors of Academic Engagement

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.777[a]	.603	.599	2.19611	.603	164.076	1	108	.000	
2	.798[b]	.637	.631	2.10871	.034	10.137	1	107	.002	1.227

a. Predictors: (Constant), Perceived Usefulness of Digital Game Strategies

b. Predictors: (Constant), Perceived Usefulness of Digital Game Strategies, School_Type

c. Dependent Variable: Academic Engagement Level in Biology

Table 6 presents the hierarchical regression analysis model of academic engagement predictors. The results of Model 1 show that the variance of biology student engagement accounted for 60.3% (R^2=.603, F(1,108)=164.076, p<.001) by perceived digital game strategies. Although the addition of school type does not increase the explanatory power significantly (cumulative ΔR2 =.034, ΔF(1,107) = 10.137, p = .002), it does introduce a significant variance change. This statistical output validates both, as they are both valid predictive dimensions, which means that the Null Hypothesis 1 is rejected.

Table 7. Analysis of Variance (ANOVA) for the Regression Models

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	791.320	1	791.320	164.076	.000[b]
	Residual	520.871	108	4.823		
	Total	1312.191	109			
2	Regression	836.397	2	418.199	94.048	.000[c]
	Residual	475.794	107	4.447		
	Total	1312.191	109			

a. Dependent Variable: Academic Engagement Level in Biology

b. Predictors: (Constant), Perceived Usefulness of Digital Game Strategies

c. Predictors: (Constant), Perceived Usefulness of Digital Game Strategies, School_Type

ANOVA results diagnostics for the two hierarchical regression models are shown in Table 7. The ANOVA results show that digital game instructional strategies

(Model 1) has an extremely significant effect (F(1,108)=164.076, p<.001). After adding school type, Model 2 is still highly significant (F(2,107)=94.048,p<.001). The value of the probabilities are well below the .05 alpha level, so the first null hypothesis is rejected. This indicates that when controlled for school type, perceived digital game instructional strategies highly predict academic engagement of biology students.

Table 8. Regression Coefficients for Predictors of Academic Engagement

Model		Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-.472	1.319		-.358	.721					
	Perceived Usefulness of Digital Game Strategies	1.043	.081	.777	12.809	.000	.777	.777	.777	1.000	1.000
2	(Constant)	-1.912	1.345		-1.421	.158					
	Perceived Usefulness of Digital Game Strategies	1.037	.078	.772	13.265	.000	.777	.789	.772	.999	1.001
	School_Type	.821	.258	.185	3.184	.002	.203	.294	.185	.999	1.001

a. Dependent Variable: Academic Engagement Level in Biology

The predictive model's coefficients are shown in Table 8. As depicted in Model 1, perceived usefulness of digital games is positively predicted engagement (Beta = .777, t = 12.809, p < .001). In Model 2, digital games remain a strong predictor (Beta = .772, t = 13.265, p < .001), while school type also emerges as a significant contributor (Beta = .185, t = 3.184, p = .002). No multi-collinearity is present as the values of VIF are close to 1.00.

Table 9: Collinearity Diagnostics for the Predictive Models

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions		
				(Constant)	Perceived Usefulness of Digital Game Strategies	School_Type
1	1	1.987	1.000	.01	.01	
	2	.013	12.519	.99	.99	
2	1	2.882	1.000	.00	.00	.02
	2	.106	5.212	.03	.05	.95
	3	.012	15.313	.97	.95	.03

a. Dependent Variable: Academic Engagement Level in Biology

Table 9 shows the collinearity diagnostics of the regression models. For model 2, the maximum condition index is 15.313 which is still below critical value of 30.0. There is not the high variance proportions on the two roots simultaneously for digital games and school type. These indicate that no severe multicollinearity exists, thus giving confidence in the structural stability of the regression predictions.

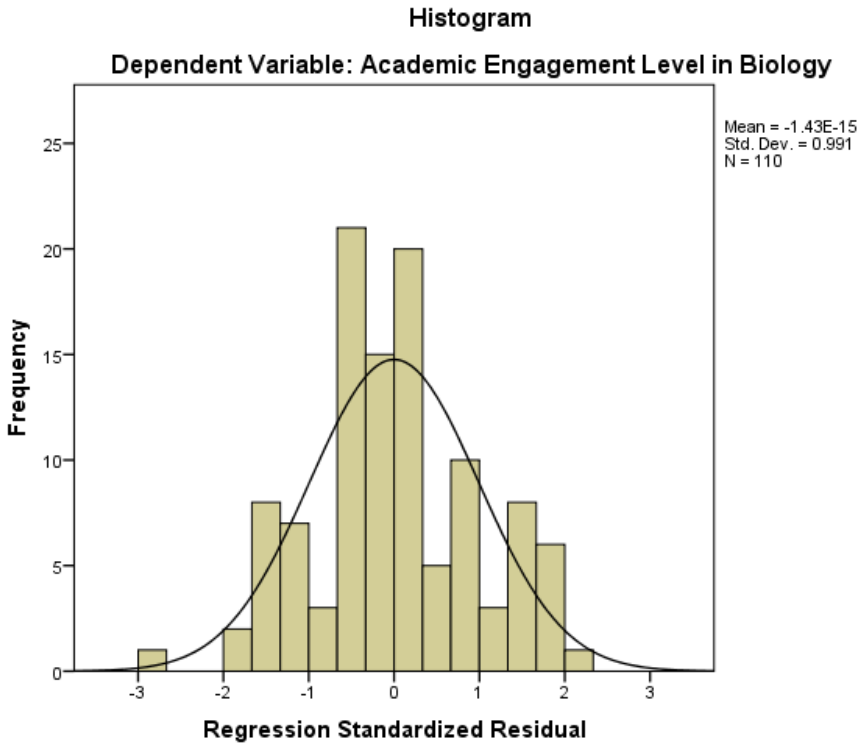

Figure 1. Histogram of Regression Standardized Residuals for Academic Engagement

Figure 1 shows the distribution of the regression standardized residual values from the academic engagement model. The curve is normal with a peak at near zero (Mean = −1.43×10−15) and a standard deviation of near unity (Std. = 0.979). Dev.=0.991). This is a confirmation of the assumption of normality for the hierarchical regression analysis. This validates the statistical basis on which the first null hypothesis was rejected, thus establishing that digital game strategies can predict student engagement.

Research Hypothesis 2: Goal-setting self-regulated learning does not significantly predict the academic engagement scores of secondary school biology students in Awka South LGA across gender categories.

Table 10. Hierarchical Regression Model Summary for Goal-Setting and Gender as Predictors

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.413[a]	.170	.163	3.17489	.170	22.179	1	108	.000	
2	.457[b]	.209	.194	3.11503	.038	5.191	1	107	.025	.996
a. Predictors: (Constant), Goal-Setting Self-Regulated Learning										
b. Predictors: (Constant), Goal-Setting Self-Regulated Learning, Gender										
c. Dependent Variable: Academic Engagement Level in Biology										

Table 10 presents the predictive power that goal-setting self-regulated learning (SRL) and gender had on biology students' engagement. The results of model 1 indicate that 17.0% of the overall variance (R^2=.170,F(1,108)=22.179, p<.001) is explained by goal-setting self-regulated learning. When gender is introduced in model 2, another 3.8% of variance change (ΔR^2=.038,ΔF(1,107)=5.191,p=.025) is achieved, resulting in a total explained variance of 20.9%. This is a statistical reason that both variables are accepted as significant predictors and thus, Null Hypothesis 2 is rejected.

Table 11. Analysis of Variance (ANOVA) for Goal-Setting and Gender Regression Models

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	223.558	1	223.558	22.179	.000[b]
	Residual	1088.633	108	10.080		
	Total	1312.191	109			
2	Regression	273.927	2	136.963	14.115	.000[c]
	Residual	1038.264	107	9.703		
	Total	1312.191	109			
a. Dependent Variable: Academic Engagement Level in Biology						
b. Predictors: (Constant), Goal-Setting Self-Regulated Learning						
c. Predictors: (Constant), Goal-Setting Self-Regulated Learning, Gender						

The analysis of variance diagnostics for the mathematical validity of the regression models are given in Table 11. A statistically stable configuration (F(1, 108) = 22.179, p<.001) is obtained for Model 1, which investigates the direct predictive power of goal-setting SRL. The statistical significance of Model 2 (F(2,107)=14.115,p<.001) remains good when the gender factor is added. Therefore, in the light of these empirical findings, Research Null Hypothesis 2 which posited that there was no significant difference between the academic engagement scores of secondary school biology students in Awka South LGA when compared across gender

is accepted with great confidence. The highly significant probability outcomes support the validity of the combined model as a valid and statistically sound predictor of student engagement.

Table 12. Regression Coefficients for Goal-Setting Self-Regulated Learning and Gender Predictors

Model		Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	9.412	1.475		6.382	.000					
	Goal-Setting Self-Regulated Learning	.465	.099	.413	4.709	.000	.413	.413	.413	1.000	1.000
2	(Constant)	10.620	1.541		6.891	.000					
	Goal-Setting Self-Regulated Learning	.541	.102	.480	5.280	.000	.413	.455	.454	.895	1.118
	Gender	-1.455	.639	-.207	-2.278	.025	-.051	-.215	-.196	.895	1.118

a. Dependent Variable: Academic Engagement Level in Biology

Table 12 shows the unstandardized and standardized scores of the predictive indicators. Based on the results of Model 1, goal setting self-regulated learning directly positively predicted academic engagement (Beta = .413, t = 4.709, $p < .001$). Goal-setting self-regulated learning is also very important with a higher contribution capacity (Beta = .480, t = 5.280, $p < .001$) in Model 2. Also, gender is a statistically significant predictor in the combined configuration (Beta = -.207, t = -2.278, p = .025). The collinearity diagnostics also indicate that the estimation is safe since the Variance Inflation Factors are much lower than the conservative limit of 5.00.

Table 13. Coefficient Correlations and Covariances for the Regression Models

Model				Goal-Setting Self-Regulated Learning	Gender
1	Correlations	Goal-Setting Learning	Self-Regulated	1.000	
	Covariances	Goal-Setting Learning	Self-Regulated	.010	
2	Correlations	Goal-Setting Learning	Self-Regulated	1.000	-.325
		Gender		-.325	1.000
	Covariances	Goal-Setting Learning	Self-Regulated	.010	-.021
		Gender		-.021	.408

a. Dependent Variable: Academic Engagement Level in Biology

Table 13 shows the structural diagnostic values for the model coefficients for both the regression models. The model in Figure 1 represents a stable variance model with an independent predictor covariance of .010. The correlation between the estimated coefficients of model 2 is low −.325. The goal-setting self-regulated learning and gender coefficients have a very small off-diagonal overlap as shown in the corresponding covariance structure (Covariance = -.021); the standard error of the goal-setting self-regulated learning coefficient is .010 and of the gender coefficient is .408. Those low correlation and covariance values again support the assumption that the two predictor variables have different information content, and the end result of the hierarchical regression analysis provides no inflationary overlap.

Table 14. Collinearity Diagnostics for Goal-Setting and Gender Models

				Variance Proportions		
Model	Dimension	Eigenvalue	Condition Index	(Constant)	Goal-Setting Self-Regulated Learning	Gender
1	1	1.979	1.000	.01	.01	
	2	.021	9.640	.99	.99	
2	1	2.926	1.000	.00	.00	.01
	2	.053	7.447	.11	.12	.99
	3	.021	11.724	.88	.87	.00

a. Dependent Variable: Academic Engagement Level in Biology

Secondary hierarchical regression setup collinearity diagnostics presented in Table 14. The largest condition index for Model 2 is 11.724, much smaller than the usual 30.0 value suggesting bad multiple linear regression. Further, there are no high simultaneous values (above .90) for variance proportions for goal-setting self-

regulated learning and gender on any individual dimension root. These diagnostics establish that the regression model is structurally reliable and has no significant data redundancy.

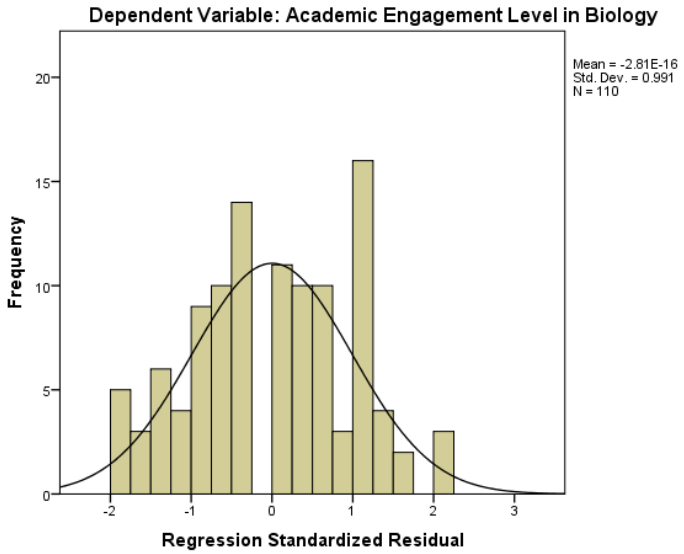

Figure 2. Histogram of Regression Standardized Residuals for Goal Setting and Gender

The second histogram shows the distribution of regression standardized residuals for the model that evaluates goal setting and gender. The distribution curve is very close to a normal bell-shaped curve centered around zero and a standard deviation of 0.991. This shows that the assumption of normality is met for the hierarchical regression analysis. Therefore, the second null hypothesis is rejected, as the statistical evidence is sufficient to conclude that goal setting self-regulated learning is still a valuable predictor for each gender.

Hypothesis 3: Perceived digital game instructional strategies and goal-setting self-regulated learning does not jointly significantly predict the academic engagement levels of secondary school biology students in Awka South LGA

Table 15. Correlation Matrix between Digital Game Strategies, Goal-Setting, and Academic Engagement

		Academic Engagement Level in Biology	Perceived Usefulness of Digital Game Strategies	Goal-Setting Self-Regulated Learning
Pearson Correlation	Academic Engagement Level in Biology	1.000	.777	.413
	Perceived Usefulness of Digital Game Strategies	.777	1.000	.388
	Goal-Setting Self-Regulated Learning	.413	.388	1.000
Sig. (1-tailed)	Academic Engagement Level in Biology	.	.000	.000
	Perceived Usefulness of Digital Game Strategies	.000	.	.000
	Goal-Setting Self-Regulated Learning	.000	.000	.
N	Academic Engagement Level in Biology	110	110	110
	Perceived Usefulness of Digital Game Strategies	110	110	110
	Goal-Setting Self-Regulated Learning	110	110	110

Table 15 shows that all three analytical variables are positively related and do have statistically significant relationships with each other (N = 110). The perceived usefulness of digital game strategies shows a significant high positive correlation with secondary school students' academic involvement in biology ($r = .777$, $p < .001$). Goal-setting self-regulated learning has a moderate positive correlation with academic engagement ($r = .413$, $p < .001$) and a similar moderate correlation with digital game strategies ($r = .388$, $p < .001$).

Table 16. Analysis of Variance (ANOVA) for Joint Predictive Model

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	810.401	2	405.201	86.404	.000[b]
	Residual	501.790	107	4.690		
	Total	1312.191	109			

a. Dependent Variable: Academic Engagement Level in Biology

b. Predictors: (Constant), Goal-Setting Self-Regulated Learning, Perceived Usefulness of Digital Game Strategies

The analysis of variance (ANOVA) statistics are presented in Table 16 to confirm the overall mathematical accuracy of the predictive model. The regression design provides a statistically reliable framework $F(2,107) = 86.404$, $p<.001$ which means that the accounted variance is not a random sampling error. Based on the above statistical output, Research Null Hypothesis 3 which posits that perceived digital game

instructional strategies and goal-setting self-regulated learning do not jointly significantly predict secondary school biology students' academic engagement levels in Awka South LGA is strongly rejected. In the probability index, the joint effect of both predictors is shown to be a very meaningful and statistically significant predictor of student engagement.

Table 17. Combined Model Summary and Regression Coefficients for Predictors of Academic Engagement

Model/Predictor	B	Std. Error	Beta	t	Sig.	95% CI [Lower, Upper]	Tolerance	VIF
Model Summary	R=.786	R^2=.618	Adj. R2=.610	F=86.404	p<.001	SE of Estimate = 2.16555	DW = 1.012	
1 (Constant)	-1.535	1.403		-1.094	.276	[-4.317, 1.247]		
Digital Game Strategies	.974	.087	.726	11.186	.000	[.802, 1.147]	.849	1.178
Goal-Setting Learning	.147	.073	.131	2.017	.046	[.003, .292]	.849	1.178

Dependent Variable: Academic Engagement Level in Biology

The overall regression model shown in Table 17 accounts for 61.8% of the variance in the academic engagement of the biology students (R^2= .618, F(2,107) = 86.404, p < .001). The best predictor (Beta = .726, t = 11.186, p < .001) was perceived digital game strategies. Goal setting self-regulated learning also plays a significant contribution to the model (Beta = .131, t = 2.017, p = .046). There are no multi-collinearity problems as indicated by collinearity diagnostics. Based on the unstandardized coefficients, the multiple linear regression equation is structured as follows:

$Y = -1.535 + 0.974X_1 + 0.147X_2$

Where:

- Y = Academic Engagement Level in Biology (Dependent Variable)
- X_1 = Perceived Usefulness of Digital Game Strategies
- X_2 = Goal-Setting Self-Regulated Learning

The equation shows that holding all predictors constant, the baseline engagement score is -1.535. The digital game strategies increase engagement in biology by 0.974 units per increase in strategy, and the goal-setting self-regulated learning increases engagement in biology by 0.147 units per increase in goal-setting self-

regulated learning. Both positive pathways make a substantial contribution to predicting increased levels of academic engagement.

Discussion

The descriptive metrics assessing the perceived usefulness of digital game strategies exhibited high student consensus, with the most popular responses being making abstract concepts easier to understand, and enhancing learning by playing the game. The result of this study was consistent with the study conducted by Situmorang, Suwono, Susanto, Chang, and Liu (2024) which determined that digital game based learning tools can simplify complicated biological processes in secondary school students. As for goal setting self regulated learning, the participants were reliable in terms of following standard self regulated learning practices; outlining key educational objectives prior to examinations had the highest degree of agreement. Building on this work, Shao, Tang and Zhuang (2026) noted how gamified interactive learning mechanisms enhance students' self-regulation skills and formal learning goals in science classrooms. The empirical results showed that the involvement level in overall academic in biology was high in terms of student's maximum effort in completing the assignment. This finding aligns with the results of Ruiz, Sanchez, and Figueredo (2024), which showed that gamification interventions consistently enhance the engagement behaviors of teachers and students in classrooms and schools, regardless of the type of educational context.

The results of the statistical test for the first research hypothesis indicated that perceived digital game instructional strategies significantly explained the cumulative variance of the academic engagement scores when moderated by school type, accounting for more than 60% of the variance. This discovery confirmed the results of Nadeem, Oroszlanyova, Farag (2023), who found that digital game applications are the major predictors of student engagement and enable active participation during lesson. The results of analysis on second research hypothesis indicated that the goal setting self regulated learning function had a significant variance change on the baseline model in biology in both gender groups, which showed that goal setting self regulated learning was significant predictor of biology engagement in both genders. Unlike the gender-balanced assumption, the combined model confirmed the validity of different prediction coefficients. This finding coincided with the results of Ratinho and Martins (2023) which concluded that the components of SRL directly affected student motivational pathways and their commitment to learning directly on the high school level. Finally, the third research hypothesis was supported by the evaluation which showed that perceived digital game strategies and goal setting self regulated learning were the two factors that together accounted for sixty one point eight percent of the variance in academic engagement. The finding corroborated the work of Akanni

(2026) who demonstrated that integrated gamified strategies are effective as a 'catalytic duo' that can enhance students' involvement, motivation, and interaction.

Implications of the Findings

The high baseline mean scores relating to the perceived usefulness of digital game strategies suggest that digital game interactive technology changes the way in which students engage with biological content. These strategies help to present abstract structures in a dynamic way and thus eliminate typical cognitive barriers, thereby directly fostering a deeper engagement in classrooms. The pattern is similar to the study of Enem, Enemuo, and Okafor (2025) which empirically showed that technological gamification has a positive significant effect on improving students' interest and achievement in upper basic students in local educational zones. Likewise, the statistical validation of digital game strategies as a strong predictor of students' academic studies engagement is in line with what Muogbo, Okafor & Okafor (2025) concluded that active and experiential learning strategies significantly aided the outcomes of secondary school students.

Additionally, the value of goal-setting self-regulated learning in predicting behavioral commitment suggests that strategic goal setting itself impacts behavioral commitment. It helps students to create a logical learning process by providing them with chances to describe the important points in the learning process before the examination. This is in line with the framework proposed by Ezeanyagu, Opara, and Okafor (2023) who have shown that inner motivational indicators and self-directed behaviours are good predictors of secondary school achievement in Biology. This finding suggests that personal planning instruments are generally helpful, and equally effective across various demographic differences when controlled for the moderating effect of gender.

The regression model's combined predictive power (R2=.618) has important implications for curriculum innovation in public and private institutions. Conventional teaching methods inhibit the development of self-regulated learning behaviors in learners and can also reinforce alternative conceptions in science as observed by Okafor (2019) in the region. It shows that a technological instruction must be combined with systematic self-regulation skills to maximize task concentration and effort in the joint model. This integration is crucial due to the different levels of readiness found in current classrooms, something also explored by Muogbo, Okafor, and Umezulike (2026) in relation to teachers' competence in the use of advanced educational technologies.

Finally, due to the different observations on student preferences and variance in the laboratory practical preparation, it is important that there is structured technological guidance. Digital games are able to fill the gap in teaching when abstract concepts or mathematical relationship exist and cause some difficulties in teaching as

noted by Ugonwa (2015) in related science fields. The findings suggest that school planners should move beyond local ecological/environmental studies (Aguma et al., 2026; Akinyele & Ibeh, 2020; Alegbeleye et al., 2025; Anozie et al., 2020; Nweke et al., 2020; Nweke et al., 2021; Okenmuo et al., 2023; Rotowa et al., 2020; Salami et al., 2020) and take an active interest in digital resources. Developing policies which are synchronised and include gamification and goal setting approaches will optimise biology engagement in secondary school systematically.

Conclusion

This study concludes that Perceived Digital Game Instructional Strategies and Goal setting Self-Regulated Learning are significant factors that determine academic engagement of secondary school biology students in Awka South LGA. The empirical results confirm that the two components of digital gameplay and the three aspects of SRL are significant predictors of classroom involvement, assignment completion and conceptual focus of learners. In particular, the use of digital games enables the elucidation of the biological structures that are more abstract, which leads to a higher level of interest among students and concentration on the task. At the same time, students develop a system of self-regulation practices, such as setting up clear goals before tests which help them to stay disciplined to keep up active learning among boys and girls in different schools. The structural regression models support the hypothesis that each separate model has a unique positive effect on students' participation, but the simultaneous application of these models has the greatest predictive effect on the global participation of students. The collective efficacy is a sign of the importance of modernizing science teaching with its traditional ways. In view of this, it is recommended that strategic goal setting behaviors should be adopted alongside contemporary technological structures as a valid pedagogical pathway to optimize students' engagement indicators. These co-ordinated methods successfully convert student learning into an active and ongoing investment in education in biology classrooms.

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