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Predictors of Digital Literacy Using Game Based Learning Approach and Student Engagement

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ABSTRACT

Aim: This study aimed to examine the predictive relationship between game-based learning (GBL), student engagement, and digital literacy among senior high school students in selected public schools in Maramag, Bukidnon. Specifically, it sought to determine how GBL features and levels of engagement influence students' digital competence across multiple domains.

Methodology: A quantitative predictive–correlational research design was employed with 306 Grade 11 and 12 senior high school students as respondents. Validated survey instruments measured students' knowledge, perceptions, and attitudes toward GBL; their affective, behavioral, and cognitive engagement; and digital literacy across six dimensions. Data were analyzed using descriptive statistics, Pearson correlation, and multiple regression.

Results: Findings revealed high levels of digital literacy, particularly in communication and critical thinking skills, as well as generally high student engagement and favorable perceptions of GBL. Device security emerged as the weakest area of digital literacy. Correlation analysis showed significant positive relationships between GBL, student engagement, and digital literacy, with cognitive engagement emerging as the strongest predictor. Regression analysis confirmed that both GBL and engagement significantly predict digital literacy, jointly explaining 31.4% of its variance.

Conclusion: The study concluded that interactive and engaging learning environments, particularly those integrating game-based learning, play a vital role in enhancing digital competence in science education. Strengthening cognitive engagement and addressing weaknesses in device security and GBL attitudes are recommended. The findings offer practical implications for educators, curriculum developers, and policymakers in designing inclusive, technology-enhanced science learning environments.

Keywords: Science education, game-based learning, student engagement, digital literacy, multiple regression, Philippines

INTRODUCTION

Problem Statement

The rapid advancement of digital technology has significantly altered the ways individuals access, process, and convey information, particularly in science education, where inquiry, simulation, and experimentation increasingly rely on digital tools. Despite these changes, many students continue to exhibit insufficient digital literacy, particularly in evaluating scientific information, ensuring online safety, and practicing ethical digital conduct (Anthonysamy et al., 2020; Erwin & Mohammed, 2022). Poor digital literacy has also been linked to socioeconomic disadvantages, limited access to reliable internet, insufficient teacher training, and outdated policies (Mangarin & Climaco, 2024). These gaps present critical challenges for science classrooms, where students must navigate complex digital environments responsibly and effectively.

LITERATURE REVIEW

Structured digital literacy instruction becomes increasingly necessary in science classrooms, where the

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curriculum increasingly incorporates technology-enhanced learning, such as virtual labs and digital simulations. Furthermore, the necessity of incorporating digital safety practices into science curricula is further emphasized by the low proficiency in device security among students (Ruoslahti et al., 2021; Pepito & Acledan, 2022). These digital competencies are not merely technical; they are the foundation of scientific inquiry in the 21st century.

Game-based learning (GBL) is a promising pedagogical tool in this context. Multiple studies confirm that game-based learning (GBL) cultivates essential digital competencies by offering immersive and interactive educational settings (Fadhli et al., 2023; Li et al., 2024). Educational games have the potential to simulate natural phenomena, encourage inquiry, and enable learners to apply abstract scientific concepts in realistic scenarios within the context of science education.

Student engagement, encompassing cognitive, emotional, and behavioral dimensions, has been consistently associated with enhanced learning outcomes in STEM disciplines. Holm (2024) states that students who are cognitively engaged tend to demonstrate enhanced critical evaluation skills and technological adaptability, which are crucial in the field of science. According to Getenet et al. (2024), students with high engagement demonstrate enhanced digital literacy, particularly in online science learning contexts. Further research indicates that students' positive engagement with digital games improves their scientific reasoning and digital fluency (May, 2021; Balaskas et al., 2023).

Theoretical Framework

This research is based on Ng's (2012) Digital Literacy Framework, which delineates the technical, cognitive, and socio-emotional elements necessary for digital competence. This framework is rooted in Vygotsky's (1978) constructivist theory, highlighting the importance of interaction and experiential learning, which are fundamental to game-based learning. Finally, Csikszentmihalyi's (1975) Flow Theory suggests that immersive and engaging learning experiences in science education enhance student motivation and skill development, especially within digital contexts.

It is important to explore how these ideas work together in the classroom, especially in science education, where digital competence is becoming increasingly important. Moreover, engagement and game-based learning (GBL) are frequently examined in isolation, resulting in a lack of comprehensive understanding regarding their joint influence on the development of digital literacy. Many recent studies focus on describing or finding relationships instead of using models to predict outcomes.

The conceptual framework of the study as shown in Figure 1. It outlines the relationships between the key variables that influence digital literacy among students. At the core of the framework are two independent variables: game-based learning approach and student engagement, both of which were hypothesized to predict and enhance digital literacy.

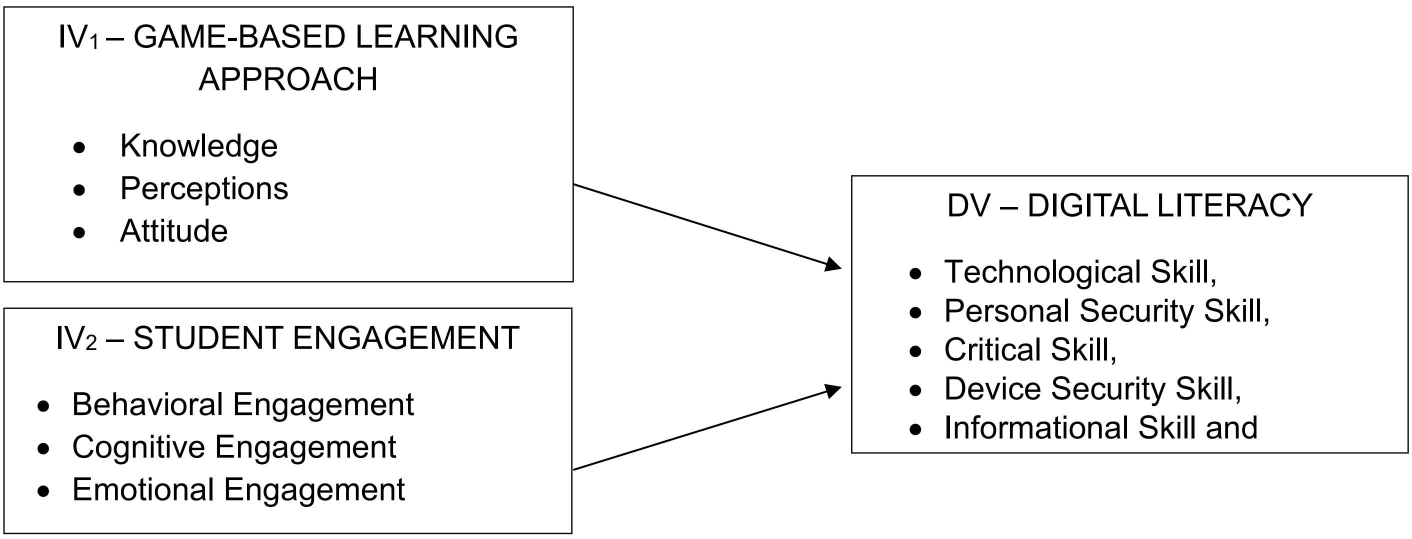

Figure 1. The Conceptual Framework

In this study, the game-based learning approach serves as one of the independent variables. It refers to the integration of educational games—featuring simulations, challenges, rewards, and other gamified elements—into the learning process. De Guzman Quinto (2022) highlighted that students exhibit strong knowledge and a positive attitude toward this approach. This variable is measured through three components: knowledge, the factual and conceptual understanding of how educational games enhance science learning.; perceptions, the evaluative judgment of students regarding the effectiveness of GBL in improving understanding.; and attitudes, the emotional orientation and willingness to engage in game-based science activities.

The second independent variable is student engagement, defined as the student's active involvement and interactions with learning activities, processes, contexts, and conceptualized as a multidimensional concept consisting of behavioral, cognitive, and affective aspects (Wang, et.al, 2020). Behavioral engagement refers to students' participation in digital science activities; cognitive engagement, which involves the use of reasoning, problem-solving in scientific tasks and affective engagement, referring to students' interest and enjoyment in science digital learning.

The dependent variable is digital literacy, which refers to the ability to effectively locate, evaluate, create, and communicate information using digital tools. As outlined by Rodríguez-De-Dios et al. (2016), digital literacy includes six dimensions: technological skills (ability to operate digital tools and software), personal security (awareness of online privacy and data protection), critical skills, (ability to analyze and evaluate digital content), device security (knowledge of protecting devices from threats), and informational and communication skills, (effective search, synthesis, and sharing of digital information).

Research Gap

Although GBL and student engagement have been widely studied, they are often examined in isolation, limiting comprehensive understanding of their combined effects on digital literacy. Moreover, prior studies frequently describe relationships rather than building predictive models. Few investigations have examined how multiple aspects of GBL (knowledge, perception, and attitude) interact with different dimensions of engagement to forecast digital literacy outcomes. This gap warrants a predictive approach.

Purpose of the Study

The goal of the study is to examine predictors of digital literacy by focusing on the impact of a game-based learning approach and varying levels of student engagement in the science subject of Grade 11 and 12 senior high school students in Maramag, Bukidnon. Specifically, the study aims to assess the impact of a game-based learning approach in terms of knowledge, perception and attitudes to students. Second, to measure the varying levels of student engagement in terms of behavioral engagement, cognitive engagement and emotional engagement. Thirdly, to ascertain the level of digital literacy in terms of technological skill, personal security skill, critical skill, devices security skill, informational skill and communication skill. Fourth, to establish if there is a significant relationship between and game-based learning and digital literacy. Fifth, to determine significant relationship between student engagement and digital literacy. Lastly, to determine the significance of the influence of game-based learning approach and student engagement on digital literacy

The following hypotheses of the study were assessed at a 0.05 level of significance: there is no significant relationship between the predictor and dependent variables, there is no significant relation between independent and dependent variables, and the predictor variable shows no relationship between the independent and dependent variables.

Significance of Study

This study holds substantial global significance as it addresses pressing challenges and emerging opportunities in science education, digital pedagogy, and learner development in the 21st century. Its implications extend across educational, technological, and policy domains, contributing to a growing body of research that seeks to transform science learning into the digital age. The primary beneficiaries of this study are senior high school science students, who engage in complex digital environments for learning, collaboration, and scientific inquiry. By identifying effective strategies rooted in game-based learning (GBL) and student engagement, the study offers practical frameworks for providing learners with the technical, cognitive, and ethical competencies essential for responsible digital citizenship and scientific reasoning.

Through the integration of GBL, the study demonstrates the pedagogical value of interactive, immersive learning environments that support student motivation and foster deeper engagement with scientific content. Such digital tools, including simulations and gamified challenges, enhance learners' conceptual understanding while simultaneously building their digital fluency—a dual imperative in modern science education. The study also contributes to the academic field by offering empirical evidence on how GBL and engagement function as predictors of digital literacy in science contexts, highlighting the importance of designing educational games that are both scientifically rigorous and learner centered.

Moreover, the findings carry important implications for policymakers, school leaders, and curriculum developers. By identifying the specific factors that influence digital literacy, particularly within the GBL framework, the study offers research-based understanding that can inform the creation of inclusive and adaptable science programs tailored to the needs of diverse learners. This aligns with the broader objectives of Sustainable Development Goal (SDG) 4: Quality Education, particularly in promoting equitable access to innovative, technology-enhanced learning opportunities.

At the national level, the research provides valuable guidance for the Philippine Department of Education (DepEd) in strengthening science curriculum implementation across the K to 12 Senior High School STEM strand. Both public and private schools can benefit from these findings, as they provide practical strategies to enhance digital use, increase student involvement, and develop scientific skills. Teachers can apply these insights to improve their teaching methods, while educational leaders can use the results to support teacher training, manage resources, and update policies.

In the end, this study supports building science learning spaces that prepare students for the future, helping them succeed academically and engage actively in the digital economy. By making digital literacy a key part of science education changes, it promotes a vision of learning that is creative, inclusive, and important worldwide.

METHOD

Research Respondents

The respondents in this study were senior high school students who are at least 18 years old at the time of data collection and have already taken their science core subjects, Earth and Life Science and Physical Science.

This study was conducted in selected public secondary schools within the Division of Bukidnon, specifically Bukidnon National School of Home Industries, and Dologon National High School. Both schools are situated in the Municipality of Maramag, Bukidnon which serves as an educational, agricultural, and commercial hub in the province due to its central location and accessibility. The selected schools serve learners from both urbanizing centers and rural barangays, including those from geographically isolated and economically disadvantaged areas.

The researcher compiled an approximate number of 1500 Grade 11 and 12 students. To get the minimum recommended sample size, this study used raosoft.com. Rao soft recommended 306 respondents to be part of this study which has a percentage of 5 as a margin of error that can be tolerated and a percentage confidence level of 95 for uncertainty. This sampling was based on random selection and classification, which involved selecting a subset of the population's elements.

When using stratified sampling, a probability sampling approach, the substantial number of populations is evaluated in relation to a certain variable's properties. In addition, by doing this sample selection, bias is reduced, and specific demographic segments are protected from being either overrepresented or underrepresented in the chosen sample (Ilyasu & Etikan, 2021)

Materials and Instrument

The researcher used survey questionnaires taken from different studies and adapted to the context of this study and respondent. In this study, there are three sets of questionnaires. The independent variable questionnaire is on game-based learning approach which was adapted and modified from De Guzman Quinto (2022). A total of 15 items, including five under the knowledge indicator, six under the perceptions indicator, and four under the attitude's indicator were developed to evaluate the impact of game-based learning on students.

The second set of questionnaires is about the other independent variable, the student engagement questionnaire. This questionnaire is adapted from the study of Hart et al. (2011). Using three indicators, this variable questionnaire was adapted to assess the level of student engagement of SHS students who already have taken Science core subjects. With a total of 25 statements, the affective has five statements, and 10 statements for both the behavioral cognitive aspects.

The third questionnaire is for the dependent variable, digital literacy. This instrument was adapted and modified from the study of Rodriguez-de-Dios et.al (2016). The questionnaire is composed of six indicators, namely, technological skill, personal security skill, critical skill, devices security skill, informational skill, and communication skill with an overall 25 items.

Each item in the questionnaire was rated using a 5-point Likert scale to assess the respondent's level of agreement. The scale is as follows: 1 – Strongly Disagree: the respondent completely disagrees with the statement. 2 – Disagree: the respondent disagrees with the statement. 3 – Neutral: the respondent neither agrees nor disagrees; they may be undecided or feel indifferent. 4 – Agree: the respondent agrees with the statement. 5 – Strongly Agree: the respondent fully concurs with the statement.

A panel of experts received this initial compilation of question items for formal assessment and expert comments. The experts evaluated the items' appropriateness, relevance, and language usage to determine the content validity. After the instrument was revised considering the experts' suggestions, it was pre-tested on 30 Senior High School students who were chosen at random.

To ensure the validity and reliability of the data collected, the researcher employed internal consistency as a method of validation, measured using Cronbach's alpha coefficient. This statistical measure was used to assess the extent to which the items in the questionnaire were consistently measuring the same underlying statement.

Design and Procedure

The study adopted a quantitative research approach, which focused on collecting and analyzing numerical data to determine the relationships among the variables: digital literacy, the game-based learning approach and student engagement. This approach is fitting because it entails objective measurement, statistical analysis, and the ability to generalize findings to similar populations. Objective assessment is a tool which measures variables using standardized tools, ensuring reliability and validity. Hypothesis testing enabled the researcher to assess the hypotheses about the predictive relationships among the variables.

The study employed a predictive correlational research design to determine the extent to which game-based learning (GBL) and student engagement predict digital literacy. This approach focused on identifying relationships among variables and using them to forecast outcomes.

First, descriptive statistics were used like mean, standard deviation and frequencies to summarize data on demographics, GBL features, engagement levels, and digital literacy scores. This provided an overview of the data distribution.

Second, Pearson Correlation was used to examine initial relationships between variables before running regression. This determined whether variables are significantly correlated and suitable for regression analysis.

Finally, multiple regression was employed to analyze the relationship between a single dependent variable and several independent variables. The objective of multiple regression analysis is to use independent variables whose values are known to predict the value of the single dependent value (Moore et al., 2006). Multiple regression was used to determine how game-based learning (GBL), and student engagement predict digital literacy. This method quantified the relationship between independent variables (GBL features, engagement) and the dependent variable (digital literacy), providing predictive insights.

In conducting this research, the researcher adhered to all established standards to ensure the study's integrity. First, a thoroughly analyzed and adapted questionnaire was translated and presented to the evaluators for review. After incorporating necessary corrections and adjustments based on the validators' feedback, the researcher prepared the questionnaire for formal validation. To further enhance its credibility, an external validator was engaged. Second, once the questionnaire was finalized, the researcher organized all necessary requirements for validation through UMERC. The researcher submitted a copy of the manuscript to UMERC under Protocol No. UMERC-2025-138 for review and recommendations for ethical considerations.

In conducting this research, the researcher prioritized the ethical considerations and safety of each participant. Participation in this study is entirely voluntary, with no coercion involved. Regardless of the study's findings, the researcher is committed to maintaining the confidentiality and credibility of all respondents. Participants have the right to withdraw without any penalties. The researcher ensured the protection of all confidential data collected. Respondents may choose whether to include their names when answering the questionnaire. Additionally, the researcher explained the potential benefits of the study's outcomes.

Participants were senior high school students who were at least 18 years old at the time of data collection. Students coming from private schools and students from other grade levels were not part of the study. Respondents who are not senior high school students or are below 18 years old were excluded from participating in the study. They had the right to withdraw from the study at any time without facing any consequences. Their decision to leave did not affect their grades, school activities, or relationships with teachers or classmates. The researcher also reserved the right to withdraw a participant if they are unable to complete the required activities, if their well-being is at risk, or if their behavior disrupts the study process.

Since target respondents are students, requests were addressed to school administrators for the conduct of the study. The school principals who were requested to take part in this study gave their consent and approval for the researchers to collect information. After receiving approval, the researcher gave the questionnaires to the participants. The respondents were informed that the confidentiality of their answers would be strictly upheld, and the findings would be used for both study and professional growth. To complete the questionnaire, the researcher facilitated student-respondents to use their free time in answering the questionnaires. The researcher tabulated and processed the data for the statistical analysis after retrieving the questionnaire.

Additionally, the researcher carefully analyzed and understood each concept and idea presented by various authors for each variable, ensuring that no claims are made on the intellectual contributions of others. The study properly acknowledged and cited all relevant authors and proponents. The researcher also used accurate definitions for key terms and applied an appropriate model for the research. To ensure the integrity and credibility of this study, several ethical measures were followed. All written content and data were screened using an anti-plagiarism tool to verify originality and prevent any form of academic dishonesty. Proper citations and referencing were applied to give credit to original sources.

Moreover, the researcher asserted that she has no ownership over the work of others and was committed to maintaining integrity in reporting the study's results. The data collected were presented honestly, with no alterations or additions. The researcher fully recognized her contribution to the study while acknowledging that she is the primary author, with her advisor serving as the co-author.

RESULTS AND DISCUSSIONS

This section presents the findings of the study that examined the predictive relationship between the game-based learning approach, student engagement, and digital literacy.

Level of Game Based Learning Approach

The table presents the mean scores and standard deviations for three key indicators—*Knowledge*, *Perception*, and *Attitude*—in relation to the Game-Based Learning Approach. The overall mean score of 3.55 (SD = 0.57) indicates a high level of receptiveness toward GBL. Participants demonstrated substantial *knowledge*, favorable *perceptions*, and generally supportive *attitudes*, suggesting a positive orientation toward this pedagogical approach.

Table 1 Level of Game Based Learning Approach

Indicators	**SD**	**Mean**	**Descriptive Level**
Knowledge	0.64	3.67	High
Perception	0.70	3.61	High
Attitude	0.75	3.38	High
Overall	**0.57**	**3.55**	**High**

The high mean score in the *knowledge* dimension (M = 3.67) reflects a strong understanding of how educational games support science concepts. This echoes the studies by Fadhli et al. (2023) and Cabero-Almenara et al. (2022) which state that Game Based Learning (GBL) improves digital skills, especially when science topics are taught using interactive multimedia like simulations of biological processes or games in physics.

Perception (M = 3.61) indicates that students view GBL positively within science contexts, resonating Chainilpan et al. (2024), who emphasized how well-designed science games can improve comprehension of complex topics such as cell division or climate systems.

However, the *attitude* score (M = 3.38) was the lowest, which might be attributed to students who are not used to or do not have enough access to science-specific educational games, supporting Kiliç (2022), who highlighted the need to combine GBL with traditional teaching for better science learning.

Student Engagement

The table presents the mean scores and standard deviations for three key indicators—affective, behavioral, and cognitive student engagement. The mean score of 4.11 (SD = 0.48) signifies a high level of overall engagement.

Table 2 Level of Student Engagement

Indicators	**SD**	**Mean**	**Descriptive Level**
Affective Engagement	0.61	4.33	Very High
Behavioral Engagement	0.58	3.90	High
Cognitive Engagement	0.61	4.10	High
Overall	**0.48**	**4.11**	**High**

Affective engagement (M = 4.33) suggests that students enjoy participating in science activities, particularly when lessons are enhanced through gamified or inquiry-based approaches. This supports findings by Getenet et al. (2024) and Singhi & Anmol (2025), who found that students demonstrate higher emotional engagement when interacting with virtual science labs or simulations.

Behavioral engagement (M = 3.90) indicates active participation in science learning tasks, such as using digital tools for data collection or simulations in biology and chemistry. This is in consonance with Wang et al. (2025) who emphasized that behavioral engagement is a crucial factor in science achievement, especially in digitally enhanced classrooms.

Cognitive engagement (M = 4.10) shows that students apply analytical thinking and problem-solving strategies in digital science activities. This is parallel to Holm (2024) who emphasized that such cognitive engagement fosters critical scientific reasoning, especially in virtual environments where students test hypotheses or manipulate scientific variables.

Level of Digital Literacy

The overall level of *digital literacy* among respondents was found to be high, with a mean of 3.91 and a standard deviation of 0.57, indicating that most participants possess a strong grasp of digital tools and competencies required in the modern technological environment.

Table 3. Level of Digital Literacy

Indicators	SD	Mean	Descriptive Level
Technological Skill	0.67	3.91	High
Personal Security Skill	0.71	3.86	High
Critical Skill	0.71	3.92	High
Device Security Skill	0.86	3.66	High
Informational Skill	0.71	3.84	High
Communication Skill	0.69	4.27	Very High
Overall	**0.57**	**3.91**	**High**

The high score in communication skills suggests that students are adept at using digital tools to present scientific findings or collaborate in virtual labs. This agrees with Wu et al. (2022) who confirmed that video conferencing and collaborative tools enhance communication in science classrooms, especially during remote experiments.

Critical skills (M = 3.92) reflect students' ability to evaluate scientific information and data accuracy, an essential competency in the digital age. Similarly, Shuhidan et al. (2023) emphasized that digital literacy in science requires the ability to assess the credibility of online sources, especially when engaging in citizen science projects or virtual research.

Device security skills, with the lowest score (M = 3.66), highlight a weakness in protecting scientific data and digital tools. This gap aligns with Pepito and Acledan (2022), who found that science students often lack training in securing lab equipment and digital data, despite increased use of mobile labs and data collection apps.

Significance of the Relationship between Game-Based Learning Approaches and Digital Literacy

Table 4 reveals the statistical significance of the relationship between various dimensions of game-based learning approaches and six domains of digital literacy: Technological Skill (TES), Personal Security Skill (PSS), Critical Skill (CRS), Device Security Skill (DSK), Informational Skill (INS), and Communication Skill (COS).

Table 4. Significance of the Relationship between Game-Based Learning Approach and Digital Literacy

Game-Based Learning Approach	**Digital Literacy**						
	TES	PSS	CRS	DSK	INS	COS	**Overall**
Knowledge	.372** .000	.385** .000	.391** .000	.247** .000	.293** .000	.252** .000	**.407** .000**

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Perception	.368** .000	.356** .000	.408** .000	.224** .000	.309** .000	.366** .000	**.424**** **.000**
Attitude	.232** .000	.212** .000	.203** .000	.191** .001	.217** .000	.142* .013	**.253**** **.000**
Overall	**.391**** **.000**	**.382**** **.000**	**.402**** **.000**	**.267**** **.000**	**.331**** **.000**	**.306**** **.000**	**.436**** **.000**

* p<0.05, ** p<0.01, *** p<0.001

Legend:

TES – Technological Skill

PSS – Personal Security Skill

CRS – Critical Skill

DSK – Device Security Skill

INS – Informational Skill

COS – Communication Skill

All correlation coefficients are statistically significant ($p < 0.05$ or $p < 0.01$), indicating a positive and significant relationship between game-based learning and digital literacy in all dimensions. The overall correlation between game-based learning and digital literacy is strong and significant, with r = .436, indicating that students who experience higher levels of game-based learning tend to report better digital literacy.

Among individual components, perception has the strongest correlation with digital literacy (r = .424), followed by knowledge (r = .407), and then attitude (r = .253). This suggests that how students perceive game-based learning has a slightly greater influence on digital literacy than their cognitive knowledge or attitudes toward it.

In terms of digital literacy domains, Critical Skill (CRS) consistently shows the highest correlations across all game-based learning aspects, especially with Perception (r = .408) and Knowledge (r = .391). Technological Skill (TES) and Personal Security Skill (PSS) also show moderately strong correlations with all dimensions of game-based learning, particularly in the knowledge and perception aspects.

This supports Fadhli et al. (2023), who emphasized that GBL improves students' ability to critically engage with science content, such as evaluating experimental results in virtual simulations. This supports Wang & Yi (2025) who further noted that in-game feedback and science challenges improve students' technological literacy and motivation to explore scientific concepts.

Significance of the Relationship between Student Engagement and Digital Literacy

Table 5 analyzes the relationship between student engagement—specifically affective, behavioral, and cognitive engagement—and digital literacy dimensions. The correlation between student engagement and digital literacy is very strong at r = .501, indicating that higher levels of engagement predict stronger digital literacy skills.

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Table 5. Significance of the Relationship between Student Engagement and Digital Literacy

Student Engagement	**Digital Literacy**						
	TES	PSS	CRS	DSK	INS	COS	**Overall**
Affective Engagement	.167** .003	.170** .003	.244** .000	.156** .006	.164** .004	.222** .000	**.237**** **.000**
Behavioral Engagement	.321** .000	.336** .000	.398** .000	.354** .000	.384** .000	.341** .000	**.452**** **.000**
Cognitive Engagement	.442** .000	.443** .000	.478** .000	.295** .000	.429** .000	.438** .000	**.528**** **.000**
Overall	**.384**** **.000**	**.392**** **.000**	**.462**** **.000**	**.330**** **.000**	**.401**** **.000**	**.414**** **.000**	.501** .000

* p<0.05, ** p<0.01, ***p<0.001

Legend:

TES – Technological Skill

PSS – Personal Security Skill

CRS – Critical Skill

DSK – Device Security Skill

INS – Informational Skill

COS – Communication Skill

Among the types of engagement, cognitive engagement has the strongest relationship with digital literacy (r = .528), particularly with critical skill (r = .478), informational skill (r = .429), and communication skill (r = .438). Behavioral engagement also shows a strong positive correlation with all digital literacy components, especially with critical skill (r = .398) and informational skill (r = .384).

Affective Engagement, while still significant, shows relatively weaker correlations compared to the other types of engagement. This suggests that while emotional attachment to learning is important, it is the cognitive and behavioral aspects that directly contribute to digital skill acquisition.

This finding aligns with Holm (2024) and Getenet et al. (2024), who observed that science learners with high cognitive engagement perform better in virtual lab simulations, concept mapping, and digital problem-solving tasks..

Significance of the Influence of Game-based Learning Approach and Student Engagement on Digital Literacy

This section presents the analysis of the combined influence of game-based learning approaches and student engagement on digital literacy. As shown in Table 6, a multiple regression analysis was conducted to determine the extent to which these two independent variables predict the digital literacy of the respondents.

The regression model yielded a multiple correlation coefficient (R) of 0.560, suggesting a moderate to strong relationship between the combined predictors—*game-based learning approach* and *student engagement*—and the dependent variable, *digital literacy*. The regression analysis revealed that GBL and student engagement jointly explain 31.4% of the variance in digital literacy. While this is a meaningful proportion, it also highlights that 68.6% of the variance is accounted for by factors outside the current model. Possible external variables include students' home internet access and device ownership, teacher digital competence, and socioeconomic status, all of which influence opportunities for digital skill development. Future research should integrate these external variables to strengthen predictive models and provide a more holistic view of digital literacy determinants.

Table 6. Significance of the Influence Game-based Learning Approach and Student Engagement on Digital Literacy

Digital Literacy					
(Variables)		*B*	β	*t*	*Sig.*
Constant		1.036		4.185	.000
Game-based Learning Approach		.277	.275	5.262	.000
Student Engagement		.460	.387	7.400	.000
R	.560				
R^2	.314				
ΔR	.310				
F	69.381				
ρ	.000				

Moreover, the analysis yielded an F-value of 69.381 with a significance level (p-value) of 0.000, which confirms that the overall regression model is statistically significant. This means that the combination of game-based learning and student engagement is a reliable predictor of digital literacy.

The game-based learning approach indicator has a regression coefficient (B) of 0.277 and a standardized beta coefficient (β) of 0.275, with a t-value of 5.262 and a p-value of 0.000. These indicate that the game-based learning approach has a positive and statistically significant influence on digital literacy.

Meanwhile, student engagement showed an even stronger influence with a regression coefficient (B) of 0.460, a standardized beta coefficient (β) of 0.387, a t-value of 7.400, and a p-value of 0.000. This demonstrates that student engagement has a stronger and more statistically significant impact on digital literacy compared to the game-based learning approach.

This supports Zheng et al. (2023), who found that game-based science modules improved digital etiquette and motivation to learn. It also aligns with Moses (2024), who concluded that digital competence in science emerges when students are consistently engaged in digitally mediated activities.

Figure 1 outlined the relationships between GBL, student engagement, and digital literacy. Findings strongly support the framework, particularly the role of cognitive engagement, which emerged as the strongest predictor and aligns with Ng's (2012) cognitive dimension of digital literacy. The results also confirm the significance of students' perceptions of GBL, which connect to the socio-emotional aspects of the framework, reflecting the importance of motivation and willingness to adopt digital practices. However, the low scores in device security suggest a gap in the framework, as GBL and engagement may not adequately address technical safety skills. This indicates the need to expand Figure 1 in future iterations to include external variables such as access and teacher competence.

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CONCLUSION AND RECOMMENDATION

Conclusion

This study examined the predictive relationship between game-based learning (GBL), student engagement, and digital literacy in the context of science education among senior high school students. With regards to game based learning approach, findings revealed that students possessed substantial knowledge and generally favorable perceptions of the method. Attitudes were slightly less positive, suggesting the need for improved integration and scaffolding of science-related games.

Students also exhibited high levels of engagement in science learning, with affective and cognitive engagement rated the highest. These results affirm that emotionally and intellectually stimulating learning environments—often facilitated by GBL—promote deeper understanding and skill acquisition in digital contexts.

Furthermore, the results reveal a high overall level of digital literacy, particularly in communication and critical skills—essential for scientific inquiry and digital collaboration. However, device security skills emerged as a notable weakness, indicating a need for targeted digital safety instruction within science curricula.

Correlation and regression analyses confirmed that both GBL and student engagement significantly predict digital literacy, with cognitive engagement emerging as the strongest predictor. Among GBL indicators, student perceptions of the approach had the highest correlation with digital literacy. These findings reinforce the relevance of game-enhanced science education that is both conceptually rigorous and engaging. However, the unexplained variance (68.6%) suggests that other external factors—such as home internet access, teacher digital competence, and socioeconomic status—likely play a critical role in shaping digital literacy outcomes.

The study validates key theoretical models: Ng's (2012) Digital Literacy Framework, which underpins the multidimensional structure of digital skills; Vygotsky's (1978) Constructivist Theory, highlighting the role of active, socially mediated learning through digital science tools; and Csikszentmihalyi's (1975) Flow Theory, which supports the motivational power of immersive and meaningful learning experiences. The integration of these theories provides a solid foundation for advancing digital pedagogy in Philippine science classrooms.

Recommendation

The findings of this study revealed specific areas of weakness that must be addressed to ensure the comprehensive development of students' digital literacy. While the overall results showed high levels of competency and engagement, certain dimensions—particularly device security, attitude toward game-based learning, and behavioral engagement—received the lowest ratings. These areas call for targeted, stakeholder-specific interventions that are both practical and sustainable.

For students, schools should offer structured digital safety education tailored to science learning environments. Initiatives such as cybersecurity workshops, simulated digital threats in science contexts, and peer-led awareness campaigns should be implemented to enhance device security skills.

Science teachers should embed game-based learning into science lessons through curriculum-aligned simulations, science quests, and virtual experiments. Structured guided questions and reflection activities should accompany GBL activities to bridge the gap between gameplay and scientific concepts. Attitudes toward GBL can be improved by integrating it as a complement to traditional strategies and using games that reflect real-life scientific challenges.

In response to the low scores in behavioral engagement, school administrators should take a more active role in fostering digital accountability and participation. Digital accountability should be promoted through gamified monitoring tools, science-focused digital achievement badges, and incentives that encourage responsible participation in virtual science platforms. Schools should support blended learning environments where science engagement can thrive both synchronously and asynchronously.

At the curriculum level, the academe should revisit how game-based learning is positioned within instructional materials and subject curricula. Game-based science modules should be made more culturally relevant and aligned with K to 12 standards. Game content should mirror real-world scientific problems to boost student motivation and relevance. Curriculum guides should explicitly promote GBL and digital literacy integration in science instruction.

Lastly, for policymakers and education authorities, th The Department of Education should institutionalize digital literacy—especially digital safety—as a cross-cutting theme in STEM subjects. Science education policy should support the procurement of simulation-based software and invest in teacher training on digital tools and game-based strategies.

By addressing these specific gaps through tailored recommendations, this study aims to support educators, institutions, and policymakers in designing more inclusive, secure, and effective digital learning environments for science education.

REFERENCES

1. Abbott, D. (2024). Game-Based Approaches for Research Skills Training and Researcher Development: A Survey of Attitudes and Acceptance in Higher Education. ICERI Proceedings, 1, 1440–1449. https://doi.org/10.21125/iceri.2024.0429
2. Alom, M. M., & R, V. (2024). Digital literacy a paradigm shift in 21st century. In 21st Century Teaching and Learning in Classrooms (pp. 99–102). https://doi.org/10.58532/nbennurctch13
3. Anthonysamy, L., Koo, A. C., & Hew, S. H. (2020). Self-regulated learning strategies in higher education: Fostering digital literacy for sustainable lifelong learning. Education and Information Technologies, 25(4), 2393–2414. https://doi.org/10.1007/s10639-020-10201-8
4. Arjang, A., Syahputra, M., Fahruri, A., & Silva, D. (2024). The effect of digital literacy, technological adoption, and collaborative learning on student engagement in business education. International Education Trend Issues, 2(2), 339–351. https://doi.org/10.56442/ieti.v2i2.893
5. Balaskas, S., Zotos, C., Koutroumani, M., & Rigou, M. (2023). Effectiveness of GBL in the engagement, motivation, and satisfaction of 6th grade pupils: A Kahoot! approach. Education Sciences, 13(12), 1214. https://doi.org/10.3390/educsci13121214
6. Cabero-Almenara, J., Gutiérrez-Castillo, J. J., Guillén-Gámez, F. D., & Gaete-Bravo, A. F. (2022). Digital competence of higher education students as a predictor of academic success. Technology Knowledge and Learning, 28(2), 683–702. https://doi.org/10.1007/s10758-022-09624-8
7. Chainilpan, T., Prommas, N., & Plangsorn, B. (2024). Effects of Educational Digital Games with Phenomenon-Based Learning to Enhance Critical Thinking Skills of 4th Grade Students. Information Technology Journal, 20(1), 51–60. https://doi.org/10.14416/j.it.2024.v1.005
8. Chanda, C. T., Zohaib, H. S., Shogbesan, Y. O., Phiri, E. V., & Akpan, W. M. (2024). Digital Literacy in Education: Preparing Students for the Future Workforce. International Journal of Research (IJR), Vol. 11, Issue 08, 149-170, August 2024. https://doi.org/10.5281/zenodo.13347718
9. Csikszentmihalyi, M. (1975). Play and intrinsic rewards. Journal of Humanistic Psychology, 15(3), 41–63. https://doi.org/10.1177/002216787501500306
10. De Guzman Quinto, J. (2022). Development and Validation of Survey Instrument on Game-Based Learning Approach (SIGBLA). International Journal of Emerging Technologies in Learning (iJET), 17(15), 233–242. https://doi.org/10.3991/ijet.v17i15.33267
11. Erwin, K., & Mohammed, S. (2022). Digital Literacy Skills Instruction and Increased Skills Proficiency. International Journal of Technology in Education and Science, 6(2), 323–332. https://doi.org/10.46328/ijtes.364
12. Fadhli, M., Kuswandi, D., Utami, P. S., Sartika, S. B., & Barawi, N. M. H. B. (2023). Game-Based Learning and Children's Digital Literacy to Support Pervasive Learning: A Systematic review. JTP - Jurnal Technology Pendidikan, 25(3), 386–393. https://doi.org/10.21009/jtp.v25i3.38388
13. Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School Engagement: Potential of the Concept, State of the Evidence. Review of Educational Research, 74(1), 59–109. https://doi.org/10.3102/00346543074001059

14. Getenet, S., Cantle, R., Redmond, P., & Albion, P. (2024). Students' digital technology attitude, literacy and self-efficacy and their effect on online learning engagement. International Journal of Educational Technology in Higher Education, 21(1). https://doi.org/10.1186/s41239-023-00437-y
15. Hart, S. R., Stewart, K., & Jimerson, S. R. (2011). The Student Engagement in Schools Questionnaire (SESQ) and the Teacher Engagement Report Form-New (TERF-N): Examining the Preliminary Evidence. Contemporary School Psychology, 15(1), 67–79. https://doi.org/10.1007/bf03340964
16. Holm, P. (2024). Impact of digital literacy on academic achievement: Evidence from an online anatomy and physiology course. E-Learning and Digital Media. https://doi.org/10.1177/20427530241232489
17. Iliyasu, R., & Etikan, I. (2021). Comparison of quota sampling and stratified random sampling. Biometrics & Biostatistics International Journal, 10(1), 24–27. https://doi.org/10.15406/bbij.2021.10.00326
18. Li, J., Bai, J., Zhu, S., & Yang, H. H. (2024). Game-Based Assessment of students' digital literacy using Evidence-Centered Game Design. Electronics, 13(2), 385. https://doi.org/10.3390/electronics13020385
19. Kiliç, I. (2022). The effect of educational game activities applied on the academic achievement of secondary students in science education. African Educational Research Journal, 10(3), 242–249. https://doi.org/10.30918/aerj.103.22.038
20. Konold, T., Cornell, D., Jia, Y., & Malone, M. (2018). School climate, student engagement, and Academic achievement: a latent variable, multilevel multi-informant examination. AERA Open, 4(4). https://doi.org/10.1177/2332858418815661
21. Mahinay, R., & Calo, W. (2023). Exploring digital self-efficacy among junior high school learners of Alternative Learning System in Cagayan de Oro City. Humanities Commons. https://doi.org/10.17613/5q1t-hk75
22. Mangarin, R. A., & Climaco, J. L. T. (2024). Exploring Contributing Factors on Poor digital literacy of Students: A review of Existing studies. International Journal of Research and Innovation in Applied Science, IX(IX), 582–588. https://doi.org/10.51584/ijrias.2024.909051
23. May, Alan, "Gamification, Game-Based Learning, and Student Engagement in Education" (2021). Leadership Education Capstones. 55. https://openriver.winona.edu/leadershipeducationcapstones/55
24. Moses, S. (2024). Impact of digital literacy skills on students' engagement and academic performance in senior secondary schools in Chikun Local Government, Kaduna State, Nigeria. Retrieved May 22, 2025, from https://zarjes.com/ZAJES/article/view/1365
25. Murtadho, M. I., Rohmah, R. Y., Jamilah, Z., & Furqon, M. (2023). The Role of Digital Literacy in Improving Students' Competence in Digital Era. AL-WIJDÃN Journal of Islamic Education Studies, 8(2), 253–260. https://doi.org/10.58788/alwijdn.v8i2.2328
26. Nadeem, M., Oroszlanyova, M., & Farag, W. (2023). Effect of Digital Game-Based Learning on student engagement and motivation. Computers, 12(9), 177. https://doi.org/10.3390/computers12090177
27. Ng, W. (2012). Can we teach digital natives' digital literacy? Computers & Education, 59(3), 1065–1078. https://doi.org/10.1016/j.compedu.2012.04.016
28. Qiao, S., Yeung, S. S., Shen, X., Leung, J. K. L., Ng, D. T. K., & Chu, S. K. W. (2024). How competitive, cooperative, and collaborative gamification impacts student learning and engagement. https://scholarspace.manoa.hawaii.edu/items/5efd7222-50ee-46e1-b448-a21d7f9d98e7
29. Pepito, M. J. T., & Acledan, M. Y., EdD. (2022). Influence of Digital Literacy and Self-Directed Learning in the Online Learning Success of STEM College Students. International Journal of Humanities Social Sciences and Education, 9(1), 88–100. https://doi.org/10.20431/2349-0381.0901007
30. Rodríguez-De-Dios, I., Igartua, J., & González-Vázquez, A. (2016). Development and validation of a digital literacy scale for teenagers. TEEM '16: Proceedings of the Fourth International Conference on Technological Ecosystems for Enhancing Multiculturality. https://doi.org/10.1145/3012430.3012648
31. Ruoslahti, H., Coburn, J., Trent, A., & Tikanmäki, I. (2021). Cyber Skills Gaps – A Systematic Review of the Academic literature. Connections the Quarterly Journal, 20(2), 33–45. https://doi.org/10.11610/connections.20.2.04

32. Shuhidan, S. M., Yahaya, W. a. W., Hashim, H., & Baharudin, M. F. (2022). Influence of Digital Literacy on Learning Engagement among Secondary Students in Malaysia. Environment-Behaviour Proceedings Journal, 7(SI10), 135–139. https://doi.org/10.21834/ebpj.v7isi10.4114
33. Singhi, M., & Anmol. (2025). Effect of Affective and Cognitive Engagement on Academic Performance Among School Students » The International Journal of Indian Psychology. International Journal of Indian Psychology. https://doi.org/10.25215/1301.009
34. Vygotsky, L. S., & Cole, M. (1978). Mind in Society: Development of Higher Psychological Processes. Harvard University Press.
35. Wang, M., Henry, D. A., & Degol, J. L. (2020). A development-in-sociocultural-context perspective on the multiple pathways to youth's engagement in learning. In Advances in motivation science (pp. 113–160). https://doi.org/10.1016/bs.adms.2019.11.001
36. Wang, P., & Yi, H. (2025). A bibliometric analysis of digital game-based learning in educational contexts. Research and Practice in Technology Enhanced Learning, 20, 037. https://doi.org/10.58459/rptel.2025.20037
37. Wang, Y., Zuo, M., He, X., & Wang, Z. (2025). Exploring students online learning behavioral engagement in university: factors, academic performance and their relationship. Behavioral Sciences, 15(1), 78. https://doi.org/10.3390/bs15010078
38. Wu, Y., Sun, Y., & Sundar, S. S. (2022). What Do You Get from Turning on Your Video? Effects of Videoconferencing Affordances on Remote Class Experience During COVID-19. Proceedings of the ACM on Human-Computer Interaction, 6(CSCW2), 1–21. https://doi.org/10.1145/3555773
39. Zheng, Y., Zhang, J., Li, Y., Wu, X., Ding, R., Luo, X., Liu, P., & Huang, J. (2023). Effects of digital game-based learning on students' digital etiquette literacy, learning motivations, and engagement. Heliyon, 10(1), e23490. https://doi.org/10.1016/j.heliyon.2023.e23490