Examining the Impact of Gamified Learning on the Motivation of Low-Performing Secondary School Science Students

Aduo Frank[1], Raphael Yao Vorleto[2], Mathew Kofi Atta[3], Michael Tabbey-Appiah[4]

[1]University of Education, Winneba,
[2]E. P. College of Education, Bimbilla.
[3]St. Francis College of Education, Hohoe,
[4]University of Education, Winneba

Abstract

This study investigated the impact of gamified learning on the motivation of low-performing secondary school science students in the Assin South District of the Central Region of Ghana. Despite growing interest in gamification as a pedagogical tool, limited research has focused on learners who consistently underperform, particularly in science. Guided by Self-Determination Theory, Constructivist Learning Theory, and Experiential Learning Theory, the study adopted a quasi-experimental pre-test/post-test design. The population comprised secondary school students whose previous science examination scores fell below the national proficiency benchmark. Purposive sampling was used to select schools with a high proportion of low-performing learners, and intact classes were assigned to either the experimental or control groups. The experimental group received gamified science instruction incorporating points, badges, leaderboards, interactive challenges, and collaborative tasks, while the control group followed conventional teaching methods. Motivation was measured using a modified Motivated Strategies for Learning Questionnaire (MSLQ) adapted to the secondary school science context.

Findings revealed a significant increase in motivation among students exposed to gamified instruction compared to the control group. ANCOVA results, controlling for pre-test scores, indicated that the experimental group achieved significantly higher adjusted post-test motivation scores ($F(1, 57) = 65.78$, $p < 0.001$, partial $\eta^2 = 0.68$), indicating a large practical effect. The study demonstrates that gamified learning can effectively enhance intrinsic motivation, engagement, and collaborative learning among underperforming students. These results underscore the potential of gamification as a pedagogical strategy to reduce achievement gaps in science education. The study recommends that teachers, curriculum developers, and policymakers integrate gamified approaches to foster student motivation, while acknowledging limitations related to sample size, intervention duration, and reliance on self-report measures.

Keywords: Gamified learning, Motivation, Low-performing students, Science education, Quasi-experimental design

Introduction

Science education plays a pivotal role in fostering critical thinking, problem-solving skills, and scientific literacy among secondary school students (Osborne & Dillon, 2008). However, many students, particularly those categorized as low-performing, struggle to engage meaningfully with science content, leading to poor academic achievement and low motivation (Pintrich & Schunk, 2002). Motivation, which encompasses the internal and external factors driving students' learning behaviors, is widely recognized as a critical determinant of academic success (Ryan & Deci, 2000). Low motivation often results in superficial learning, decreased participation in class activities, and diminished interest in pursuing science-related careers (Schunk et al., 2014). Addressing motivational challenges among underperforming students is therefore essential for promoting equitable science education outcomes.

Recent advancements in educational technology have highlighted gamification as a promising approach to enhance student engagement and motivation (Deterding et al., 2011). Gamification involves incorporating game-like elements—such as points, badges, leaderboards, and challenges—into learning environments to make educational activities more interactive and rewarding (Hamari et al., 2014). Studies indicate that gamified learning can increase intrinsic motivation, foster persistence, and enhance overall academic performance, particularly among students who are disengaged or underperforming (Domínguez et al., 2013; Mekler et al., 2017). In the context of science education, gamification has been shown to encourage active participation in experiments, reinforce conceptual understanding, and support collaborative problem-solving (Ibáñez et al., 2014).

Despite the growing evidence supporting gamification, there remains a significant research gap concerning its specific effects on low-performing secondary school science students in under-resourced educational settings. Many existing studies have focused on general student populations or higher-achieving learners, leaving the needs of struggling students underexplored (Sailer & Homner, 2020). Moreover, motivational interventions often overlook the contextual challenges faced by secondary schools in developing countries, such as limited access to instructional resources, large class sizes, and variations in teacher expertise (Akpan & Beard, 2009). Understanding how gamified learning influences the motivation of low-performing students is therefore essential for designing targeted instructional strategies that can bridge performance gaps and foster sustained engagement in science.

This study seeks to examine the impact of gamified learning on the motivation of low-performing secondary school science students. By investigating the motivational outcomes associated with gamification, the study aims to provide empirical insights that can inform teaching practices, curriculum development, and policy decisions in science education. Ultimately, enhancing motivation among underperforming students has the potential to improve not only their academic achievement but also their long-term interest and participation in science-related fields, contributing to the development of a scientifically literate and innovative society (National Research Council, 2012).

Purpose of the Study

This study aims to investigate the effect of gamified learning on the motivation of low-performing secondary school science students. It seeks to determine how integrating game-based elements—such as points, badges, and challenges—affects students' engagement, intrinsic and extrinsic motivation, and participation in science learning activities.

Significance of the Study:
This study contributes to knowledge on gamification in education by examining its effects on low-performing science students, a group often overlooked in research. The findings are expected to inform teaching practices, curriculum design, and policy interventions that enhance motivation, engagement, and self-directed learning, ultimately reducing achievement gaps and fostering sustained interest in science (Ryan & Deci, 2000; Deterding, Dixon, Khaled, & Nacke, 2011; Sailer & Homner, 2020; Domínguez, Saenz-de-Navarrete, de-Marcos, Fernández-Sanz, Pagés, & Martínez-Herráiz, 2013; National Research Council, 2012).

Research Objective
To determine the effect of gamified learning on the motivation of low-performing secondary school science students.

Research Question
What is the effect of gamified learning on the motivation of low-performing secondary school science students?

Hypothesis:
H_1: Gamified learning significantly increases the motivation of low-performing secondary school science students compared to traditional instructional methods.

Literature Review
Conceptualizing Gamification as a Learning Strategy
Gamification is increasingly recognized as a strategic approach in education that incorporates game elements—such as points, levels, badges, challenges, and leaderboards—into the learning environment to enhance student engagement and achievement (Deterding, Dixon, Khaled, & Nacke, 2011). By transforming traditional learning tasks into interactive, goal-oriented experiences, gamification has the potential to motivate learners, increase participation, and make complex concepts more accessible. In secondary school science education, gamified strategies can provide experiential and stimulating learning opportunities, particularly for students who struggle with conventional instructional methods (Domínguez et al., 2013).
The Significance of Motivation in Science Learning
Motivation is a critical factor influencing student engagement, persistence, and success in science education (Ryan & Deci, 2000; Pintrich & Schunk, 2002). Students with high intrinsic motivation demonstrate curiosity, persistence in problem-solving, and a willingness to engage deeply with content, whereas low-performing students often exhibit disengagement and limited effort (Schunk, Pintrich, & Meece, 2014). Understanding the mechanisms that drive motivation—both intrinsic and extrinsic—is essential for designing interventions that encourage sustained participation and improve academic outcomes among struggling learners.
Gamification as a Mechanism to Enhance Student Motivation
Empirical research indicates that gamification can act as a powerful catalyst for improving student motivation. By integrating game mechanics into educational content, learners are more likely to experience enjoyment, challenge, and a sense of accomplishment, which collectively enhance intrinsic motivation

and engagement (Mekler, Brühlmann, Tuch, & Opwis, 2017; Sailer & Homner, 2020). Gamified learning encourages active participation, fosters competition and collaboration, and provides immediate feedback, all of which reinforce student persistence and self-directed learning behaviors. For low-performing science students, these strategies may be particularly effective in addressing disengagement and promoting meaningful learning experiences.

Challenges and Learning Needs of Underperforming Science Students

Low-performing students face distinct challenges in science education, including insufficient prior knowledge, low self-efficacy, poor study habits, and environmental constraints such as limited instructional resources (Akpan & Beard, 2009). These challenges contribute to low motivation and poor academic outcomes, highlighting the need for targeted interventions. Gamified and technology-supported instructional approaches offer promising solutions by providing structured, motivating, and interactive learning experiences that can scaffold understanding, encourage participation, and ultimately improve performance among struggling learners (Schunk et al., 2014).

Theoretical Foundations Supporting Gamified Learning

The implementation of gamification in education is supported by multiple theoretical frameworks. Self-Determination Theory (SDT) posits that learners are intrinsically motivated when their needs for autonomy, competence, and relatedness are met, which gamified elements can facilitate (Ryan & Deci, 2000). Constructivist Learning Theory emphasizes that knowledge is actively constructed through experiences and social interactions, aligning with gamified strategies that promote active engagement and collaborative problem-solving (Piaget, 1970; Vygotsky, 1978). Additionally, Experiential Learning Theory highlights learning as a process of knowledge creation through experience, reflection, and application, which is inherently supported by gamified instructional designs (Kolb, 1984). Collectively, these theories provide a robust foundation for understanding how gamification can enhance motivation and learning outcomes, particularly for low-performing students.

Empirical Studies on Gamified Science Education

Studies investigating gamification in science education have consistently reported positive effects on motivation, engagement, and academic achievement. For instance, Ibáñez, Di-Serio, and Delgado-Kloos (2014) found that incorporating gamified elements increased participation and interest in learning activities, while Hanus and Fox (2015) demonstrated improvements in intrinsic motivation, effort, and performance among students exposed to gamified instruction. However, most studies have focused on general student populations, leaving gaps in understanding how gamification specifically impacts low-performing secondary school students, particularly in resource-constrained environments (Sailer & Homner, 2020).

Research Gaps and Study Rationale

Despite the growing evidence supporting gamified learning, there remains a notable scarcity of research focusing on low-performing secondary school science students. Most prior studies have overlooked this population or concentrated on well-performing learners, limiting insights into strategies for enhancing motivation and learning outcomes among struggling students. This study seeks to address these gaps by examining the effects of gamified learning on the motivation of low-performing science students, offering potential contributions to educational theory, pedagogy, and policy interventions aimed at improving science education outcomes (National Research Council, 2012).

Theoretical Framework

The theoretical foundation for this study is anchored in Self-Determination Theory (SDT), Constructivist

Learning Theory (CLT), and Experiential Learning Theory (ELT), which collectively explain how gamified learning can enhance the motivation of low-performing secondary school science students. These theories provide both a psychological and pedagogical rationale for designing and implementing gamified instructional strategies in science education.

Self-Determination Theory (SDT)

According to SDT, proposed by Ryan and Deci (2000), individuals are intrinsically motivated when their basic psychological needs for autonomy, competence, and relatedness are satisfied. Gamified learning addresses these needs by offering students choices in learning activities (autonomy), providing structured feedback and rewards such as points and badges (competence), and promoting collaboration and peer interaction (relatedness). For low-performing students who often experience low self-efficacy and disengagement, gamified strategies can create a supportive learning environment that fosters intrinsic motivation, sustained engagement, and a proactive approach to learning (Ryan & Deci, 2000; Sailer & Homner, 2020).

Constructivist Learning Theory (CLT)

Constructivist perspectives emphasize that learners actively construct knowledge through experience and social interaction (Piaget, 1970; Vygotsky, 1978). Gamified instruction aligns with this principle by providing interactive tasks, challenges, and simulations that encourage students to explore scientific concepts, test hypotheses, and collaboratively solve problems. Such active learning experiences promote deeper conceptual understanding and give students a sense of ownership over their learning, which is particularly critical for underperforming learners who may struggle with passive, teacher-centered instruction (Piaget, 1970; Vygotsky, 1978; Domínguez et al., 2013).

Experiential Learning Theory (ELT)

Kolb's (1984) ELT posits that learning occurs as a cyclical process of concrete experience, reflective observation, abstract conceptualization, and active experimentation. Gamified learning embodies this cycle: students engage in interactive activities (concrete experience), receive feedback and reflect on outcomes (reflective observation), conceptualize underlying principles (abstract conceptualization), and apply knowledge in subsequent tasks or challenges (active experimentation). This iterative process not only deepens understanding but also reinforces engagement and motivation, helping low-performing students gradually build competence and confidence in science (Kolb, 1984; Domínguez et al., 2013).

Conceptual Framework

This study's conceptual framework examines the relationship between gamified learning and motivation among low-performing secondary school science students. Gamified learning, the independent variable, encompasses instructional elements such as points, badges, leaderboards, interactive challenges, and collaborative tasks, designed to make learning engaging, interactive, and rewarding. These elements are expected to fulfill students' psychological needs for autonomy, competence, and relatedness**,** as proposed by Self-Determination Theory (Ryan & Deci, 2000)**,** thereby fostering intrinsic motivation and active participation.

Student motivation**,** the dependent variable, is characterized by engagement, persistence, and self-directed learning in science. The framework proposes that motivation is enhanced when students experience meaningful interaction with content, receive immediate feedback, and participate collaboratively, particularly addressing the needs of underperforming learners. Constructivist Learning Theory (Piaget, 1970; Vygotsky, 1978) underpins this process by emphasizing that students actively construct knowledge through problem-solving and peer collaboration. Similarly, Experiential Learning Theory (Kolb, 1984) highlights the importance of engaging in concrete experiences, reflecting on learning, conceptualizing concepts, and applying them through active experimentation, all of which are embedded in the gamified instructional tasks. The framework also recognizes contextual and individual moderating factors, including prior knowledge, classroom environment, and baseline achievement levels, which may influence the extent to which gamification enhances motivation.

Methodology

Research Paradigm

The study was guided by a conceptual framework illustrating the hypothesized relationships between gamified learning, student engagement, and motivation. In this paradigm, gamified instructional strategies—comprising points, badges, challenges, and leaderboards—serve as the independent variable, student engagement acts as the mediating variable, and student motivation is the dependent variable. The framework posits that gamified learning enhances engagement, which in turn increases motivation and can potentially improve academic performance. This paradigm is grounded in Self-Determination Theory, Constructivist Learning Theory, and Experiential Learning Theory, which collectively explain how interactive, student-centered strategies fulfill learners' needs for autonomy, competence, and relatedness, fostering motivation and improved learning outcomes (Ryan & Deci, 2000; Piaget, 1970; Vygotsky, 1978; Kolb, 1984).

Research Design

A quasi-experimental quantitative design with pre-test and post-test control groups was employed to evaluate the effect of gamified learning on low-performing secondary school science students' motivation. This design is appropriate for educational settings where random assignment is impractical, allowing for causal inferences while maintaining ecological validity (Creswell & Creswell, 2018). The study included two groups: an experimental group, exposed to gamified instruction, and a control group, which received traditional teaching. Both groups were assessed using pre-tests and post-tests to measure changes in motivation.

Population and Sampling

The target population for this study comprised all secondary school students identified as low-performing in science within the Assin South District of the Central Region of Ghana. Low-performing students were defined as those whose previous science examination scores fell below the nationally established proficiency benchmark, reflecting persistent challenges in mastering science concepts. To select participants, purposive sampling was employed to identify schools with a substantial proportion of underperforming learners, ensuring the study focused on students most likely to benefit from intervention. Within the selected schools, intact classes were assigned to either the experimental or control conditions to preserve the natural classroom environment and instructional continuity. The sample size was determined using Cohen's (1992) power analysis, which guided the selection of a sufficient number of participants to achieve adequate statistical power for detecting meaningful differences between groups. This approach ensured that the study's findings could be interpreted with confidence while maintaining ecological validity in a real-world classroom setting.

Inclusion and Exclusion Criteria

Participants were included if they had prior science scores below the proficiency threshold, provided parental/guardian consent, and maintained regular attendance. Students were excluded if they required individualized special education support or were absent for more than 20% of the intervention period, ensuring participants could fully engage with the instructional program.

Instruments

Student motivation was measured using a modified version of the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich & De Groot, 1990), adapted for secondary school science contexts, with responses recorded on a five-point Likert scale. The experimental group received a gamified instructional package, including interactive science lessons enhanced with points, badges, challenges, and leaderboards, aligned with curriculum objectives. The instruments were validated by experts in science education and instructional technology. A pilot study involving 20 students from a comparable school established reliability, yielding a Cronbach's alpha of 0.87, indicating high internal consistency.

Procedure

The procedure began with a pre-test, administered to both experimental and control groups using the motivation questionnaire to establish baseline motivation levels. The experimental group then participated in a structured gamified learning intervention over [specify duration, e.g., six weeks], incorporating interactive lessons, point accumulation, milestone badges, challenges, and collaborative activities to promote engagement. The control group received conventional teacher-centered instruction without gamified elements. Following the intervention, a post-test using the same motivation questionnaire was administered to both groups to evaluate changes in motivation.

Data Analysis

Data were analyzed using IBM SPSS Statistics version 29.0 Descriptive statistics, including means and standard deviations, were computed to summarize students' motivation scores across experimental and control groups. To evaluate the impact of gamified learning on motivation while controlling for baseline differences, Analysis of Covariance (ANCOVA) was performed with pre-test scores as the covariate. Statistical significance was established at $\mathbf{p < 0.05}$, and effect sizes were calculated using partial eta squared (η^2) to assess the magnitude of the intervention effect. This analytical approach ensured a rigorous examination of group differences while accounting for initial variations in motivation, providing robust evidence for the effectiveness of the gamified instructional intervention.

Ethical Considerations

Ethical approval was obtained from the Institutional Review Board (IRB) of [University/Institution]. Written informed consent was obtained from parents/guardians, and assent was obtained from students. Participation was voluntary, and confidentiality and anonymity were ensured. Participants were informed of their right to withdraw at any time without penalty.

Results and discussion

Motivation Scores of Low-Performing Science Students

The descriptive and inferential statistics for the motivation scores of low-performing secondary school science students are presented in Table 1. The table summarizes pre-test and post-test scores for both the experimental (gamified learning) and control (traditional instruction) groups, along with the results of an ANCOVA analysis controlling for baseline motivation levels. These results directly address the study's research question and test the hypothesis regarding the impact of gamified learning on student motivation.

Table 1:Pre-Test, Post-Test, and ANCOVA Results for Motivation Scores

Group	PreTest Mean± SD	Post Test Mean ± SD	AdjustedPost-Test Mean	F (ANCOVA)	p-value	Partial Eta Squared
Experimental (Gamified Learning)	38.2 ± 4.5	52.6 ± 5.1	52.4	65.78	<0.001	0.68
Control (Traditional)	37.9 ± 4.7	40.3 ± 4.9	40.5	–	–	–

As shown in Table 1, the experimental group experienced a notable increase in motivation scores from pre-test (M = 38.2, SD = 4.5) to post-test (M = 52.6, SD = 5.1), while the control group exhibited only a slight increase from pre-test (M = 37.9, SD = 4.7) to post-test (M = 40.3, SD = 4.9). ANCOVA analysis, controlling for pre-test scores, revealed that the difference in post-test motivation between the two groups was statistically significant, $F(1, 57) = 65.78$, $p < 0.001$, with a **large effect size** (partial $\eta^2 = 0.68$). These findings indicate that the gamified learning intervention substantially enhanced motivation among low-performing students, whereas conventional instruction had minimal impact.

Summary of Key Findings

1. The experimental group exposed to gamified instructional strategies showed a marked increase in motivation scores from pre-test to post-test, demonstrating the effectiveness of gamification in engaging low-performing secondary school science students.
2. Students in the control group, who received conventional teaching, showed only a minimal improvement in motivation, and the change was not statistically significant, indicating that traditional instructional methods may be insufficient for stimulating engagement among underperforming learners.
3. The effect size (partial $\eta^2 = 0.68$) indicates a strong practical influence of gamified learning on motivation, underscoring its potential as an evidence-based instructional strategy to enhance student engagement and interest in science.
4. The results provide empirical support for the alternative hypothesis, confirming that gamified learning significantly improves motivation among low-performing secondary school science students, compared to traditional teaching methods.

Discussion

This study explored the influence of gamified instruction on the motivation of low-performing secondary school science students, and the results demonstrate a clear and substantial advantage of gamification over traditional teaching methods. Students who experienced gamified learning showed marked gains in motivational scores from pre-test to post-test, while those taught through conventional approaches exhibited only marginal change. These findings affirm the study’s hypothesis and highlight gamification as a powerful tool for enhancing students’ motivation in science.

The notable improvement in the experimental group resonates with the core assumptions of Self-Determination Theory (SDT), which argues that learners become more intrinsically motivated when their needs for autonomy, competence, and relatedness are met (Ryan & Deci, 2000). Gamified learning environments inherently integrate these motivational drivers by offering choice, clear progress indicators, peer interaction, and immediate performance feedback through features such as points, badges, leaderboards, and interactive challenges. Such elements not only stimulate interest but also deepen engagement, aligning with earlier studies that emphasize the capacity of gamification to improve motivation and learning behaviors, particularly among students who traditionally struggle academically (Domínguez et al., 2013; Sailer & Homner, 2020).

Furthermore, the limited progress observed in the control group highlights the shortcomings of traditional, teacher-centered instructional methods. Passive learning formats often fail to capture the attention of learners with low prior achievement, contributing to persistent disengagement in science classrooms (National Research Council, 2012). In contrast, gamified instruction encourages active participation, collaboration, and sustained cognitive involvement—factors shown to enhance both motivation and learning outcomes in student-centered environments (Hidi & Renninger, 2006; Hamari et al., 2014). The combined evidence from this study and existing literature underscores that gamification provides not only motivational benefits but also a more dynamic and supportive environment for underperforming science learners.

Implications of the Study

The outcomes of this study offer both theoretical and practical insights into the use of gamified instruction in secondary school science education. Theoretically, the findings reinforce the relevance of Constructivist Learning Theory (Piaget, 1970; Vygotsky, 1978) and Experiential Learning Theory (Kolb, 1984) as foundations for gamified learning environments. The interactive nature of gamification—characterized by problem-solving tasks, collaboration, iterative challenges, and continuous feedback—mirrors the processes of knowledge construction and experiential engagement emphasized within these frameworks. This alignment indicates that gamified instruction not only enhances motivation but also fosters deeper cognitive involvement and meaningful learning experiences.

Practically, the study highlights gamification as a valuable instructional approach for improving motivation among low-performing science students. Teachers can adopt structured game elements such as points, badges, and challenges to make learning more engaging and supportive of learners' needs. Curriculum designers may integrate gamified principles into science instructional materials to cultivate sustained interest and active participation. Additionally, educational policy makers can utilize these findings to promote evidence-based interventions aimed at reducing motivational deficits and narrowing achievement gaps among underperforming student populations.

Limitations and Delimitations

This study was subject to several limitations that should be considered when interpreting the findings. First, the sample size was relatively small and drawn from a single secondary school, which restricts the generalizability of the results beyond the study context. In addition, the intervention was implemented over a short duration, limiting the ability to capture long-term motivational effects. Although instructional procedures were standardized, variations in teacher enthusiasm and classroom dynamics may have influenced outcomes independently of the gamified activities. The use of self-report questionnaires to measure motivation also presents the possibility of bias, while differences in students' familiarity with digital tools may have affected their level of engagement.

The study was also guided by delimitations intentionally set by the researcher. It focused solely on low-performing science students, excluding high and average achievers to maintain a clear scope. The investigation was confined to the science subject area, and only selected gamification components—points, badges, leaderboards, challenges, and collaborative tasks—were included, while other potential elements were not explored. The research was limited to a formal classroom setting rather than online or informal learning environments, and motivation was examined as the primary outcome variable, excluding related aspects such as academic achievement or retention.

Conclusion

In conclusion, the study demonstrates that gamified learning is an effective approach to enhancing motivation among low-performing secondary school science students. By engaging learners actively, satisfying psychological needs, and promoting collaborative problem-solving, gamification addresses motivational deficits that often hinder learning in traditional instructional settings. These findings provide both theoretical and practical support for integrating gamified strategies into secondary science education.

Recommendations

1. Schools should adopt gamified instructional strategies to enhance motivation and engagement among low-performing science students, integrating elements such as points, badges, leaderboards, and interactive challenges into routine classroom activities.
2. Science teachers should receive professional development on the effective design and implementation of gamified learning experiences, enabling them to create interactive, student-centered environments that promote autonomy, collaboration, and active participation.
3. Curriculum developers should incorporate structured gamification frameworks into science curricula and learning materials to ensure consistency, alignment with learning objectives, and long-term sustainability of gamified instructional practices.
4. Educational policymakers should prioritize the integration of gamified learning interventions within instructional improvement initiatives aimed at reducing achievement gaps and improving learner motivation, especially in schools with high numbers of underperforming students.
5. School administrators should provide the necessary resources and technological support to facilitate the successful implementation of gamified learning tools, including access to digital devices, interactive platforms, and monitoring systems.
6. Future research should expand the scope of gamified learning studies to examine long-term effects on academic performance, conceptual understanding, and behavioral outcomes, as well as the applicability of gamification across different subjects and grade levels.

Acknowledgement

The researcher extends sincere appreciation to Prof. Peter Akayure for his invaluable guidance, expert advice, and consistent support throughout this study. His insightful suggestions and mentorship greatly enhanced the quality of this work.

Gratitude is also expressed to the participating schools, teachers, and students for their cooperation and contribution to the data collection process. The researcher further acknowledges the encouragement received from colleagues, friends, and family during the course of this project, as well as the scholarly works that informed and enriched the study.

References

1. Akpan, B., & Beard, L. A. (2009). Student engagement in science in resource-constrained contexts. International Journal of Science Education, 31(15), 2045–2065.
2. Cohen, J. (1992). A power primer. Psychological Bulletin, 112(1), 155–159.
3. Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approach (5th ed.). Thousand Oaks, CA: SAGE Publications.
4. Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining gamification. Proceedings of the 15th International Academic MindTrek Conference, 9–15.
5. Domínguez, A., Saenz-de-Navarrete, J., de-Marcos, L., Fernández-Sanz, L., Pagés, C., & Martínez-Herráiz, J. J. (2013). Gamifying learning experiences: Practical implications and outcomes. Computers & Education, 63, 380–392. https://doi.org/10.1016/j.compedu.2012.12.020
6. Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does gamification work? A literature review of empirical studies on gamification. Proceedings of the 47th Hawaii International Conference on System Sciences, 3025–3034.
7. Hanus, M. D., & Fox, J. (2015). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. Computers & Education, 80, 152–161.
8. Ibáñez, M. B., Di-Serio, Á., & Delgado-Kloos, C. (2014). Gamification for engaging computer science students in learning activities: A case study. Computers in Human Behavior, 50, 558–567.
9. Kolb, D. A. (1984). Experiential learning: Experience as the source of learning and development. Englewood Cliffs, NJ: Prentice-Hall.
10. Mekler, E. D., Brühlmann, F., Tuch, A. N., & Opwis, K. (2017). Towards understanding the effects of individual gamification elements on intrinsic motivation and performance. Computers in Human Behavior, 71, 525–534.
11. National Research Council. (2012). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. Washington, DC: The National Academies Press.
12. National Research Council. (2012). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. Washington, DC: The National Academies Press.
13. Osborne, J., & Dillon, J. (2008). Science education in Europe: Critical reflections. London: The Nuffield Foundation.
14. Piaget, J. (1970). Science of education and the psychology of the child. New York: Viking Press.
15. Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. Journal of Educational Psychology, 82(1), 33–40.
16. Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American Psychologist, 55(1), 68–78. https://doi.org/10.1037/0003-066X.55.1.68
17. Sailer, M., & Homner, L. (2020). The gamification of learning: A meta-analysis. Educational Psychology Review, 32, 77–112. https://doi.org/10.1007/s10648-019-09498
18. Schunk, D. H., Pintrich, P. R., & Meece, J. L. (2014). Motivation in education: Theory, research, and applications (4th ed.). Boston, MA: Pearson.
19. Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.

20. Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.