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Impact of Digital and Non-Digital Educational Games on Grade 1 Students' Engagement and Academic Achievement

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This study investigates the impact of digital (online) and non-digital (offline) educational games on academic achievement and student engagement among Grade 1 learners in mathematics and geography, drawing on constructivist learning principles and self-determination theory to frame how game-based activities support autonomy, competence, and relatedness. A quasi-experimental pretest–posttest design was employed with two intact classes (N = 50) from a public school in Rawalpindi, Pakistan. Students were assigned to either an online game-based instructional condition or an offline game-based condition, and both groups participated in six weeks of structured game-integrated lessons. Data were collected through academic assessments, engagement checklists, motivation surveys, and teacher observations. Results show that both digital and non-digital games produced measurable gains in mathematics and geography scores, with the online group demonstrating slightly higher improvement percentages; however, independent t-tests indicated no statistically significant differences between groups ($p > 0.05$, $d = 0.12–0.18$). Engagement and motivation remained high across both conditions, with offline games generating marginally stronger participation and task completion. Correlation analyses revealed weak associations between engagement indicators and academic achievement, suggesting that academic improvement may depend on factors beyond observable engagement alone. These findings highlight that integrating both digital and hands-on game-based strategies can offer flexible, practical approaches for enhancing early-grade learning in diverse classroom settings.

Keywords: educational games, digital learning, non-digital games, game-based learning, primary education, grade 1, mathematics achievement, geography learning, students

INTRODUCTION

Educational games, both digital and non-digital, are increasingly recognized for their ability to enhance academic achievement and student engagement in early childhood

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education. These games draw on interactive, visually rich, and often hands-on features that transform abstract ideas into concrete, playful experiences. For young learners, especially in the early grades, this kind of learning environment can make challenging content feel more accessible and less intimidating. Rather than relying solely on traditional worksheets or lecture-style teaching, game-based activities invite students to explore, experiment, and receive immediate feedback, which can help them build confidence and persistence over time.

Grounded in constructivist learning theory and self-determination theory (SDT), game-based learning environments support knowledge construction through active exploration while simultaneously fostering autonomy, competence, and relatedness—three core psychological needs that enhance intrinsic motivation. Digital games, for instance, often promote autonomy and competence through adaptive feedback and individualized pacing, whereas non-digital games tend to emphasize relatedness through social interaction and collaboration.

This potential is particularly relevant in foundational subjects such as mathematics and geography, where many children struggle with abstract symbols, spatial concepts, or technical vocabulary. When educational games are purposefully integrated into instruction, research shows improvements in learning outcomes, motivation, and participation. Studies such as Ke and Vos et al. demonstrate that game-based learning environments foster active participation, strengthen interest in academic tasks, and contribute to measurable performance gains (Ke, 2008; Vos et al., 2011).

More recent empirical evidence further reinforces these claims. For example, Zhiyenbayeva et al. (2026) found that structured role-playing games significantly enhanced vocabulary development among preschool children compared to traditional instruction, highlighting the importance of socially interactive and context-rich learning environments (Zhiyenbayeva et al., 2026). Similarly, studies on digital environments such as Minecraft-based learning demonstrate that game-based platforms can enhance higher-order thinking and problem-solving skills by allowing learners to experiment within simulated contexts (Tangkui & Keong, 2023). In parallel, research on game-based interventions targeting cognitive development shows that structured gameplay can improve learners' cognitive processing and engagement, particularly when tasks are designed to encourage exploration and feedback-driven learning (Doktorová et al., 2026).

In this way, educational games do not simply make learning "fun"; they provide structured opportunities for practice, problem-solving, and meaningful engagement that support deeper understanding in early childhood classrooms.

LITERATURE REVIEW

Academic Achievement and Game-Based Learning

Research on digital and non-digital educational games with Kindergarten through Grade 5 students highlights consistent gains in academic progress, particularly in mathematics and geography. Prior work suggests that both formats create interactive and motivating

contexts that support skill development and concept mastery (Habgood & Ainsworth, 2011; Prensky, 2003).

Substantial evidence indicates that educational games can significantly improve students' academic performance by offering meaningful practice, interactive feedback, and opportunities for exploration. Digital games often include adaptive learning systems, immediate feedback, and visual modeling, which help students navigate abstract concepts in mathematics and science (Garzón & Acevedo, 2019). For example, Chen and Tu found that digital game-based learning supports higher-order thinking such as problem solving and creativity, enabling students to test ideas and receive instant feedback (Chen & Tu, 2021).

Importantly, the effectiveness of digital games is not only attributed to their technological features but also to how they structure learning experiences. For instance, Minecraft-based learning environments allow students to engage in open-ended problem-solving tasks, which can promote higher-order thinking by situating learning within meaningful, exploratory contexts rather than rote procedures. This suggests that the pedagogical design of the game, rather than the medium alone, plays a critical role in academic outcomes. However, digital game use also presents challenges, including screen fatigue, distractions, and unequal access to technology (Hamari et al., 2014). Non-digital games address some of these barriers by providing hands-on, collaborative learning experiences. Russo et al. reported that offline games, such as board and card games, promote deeper conceptual understanding—especially in mathematics—through physical manipulation and peer interaction (Russo et al., 2024). This distinction highlights an important theoretical contrast: while digital games enhance individual cognitive engagement, non-digital games strengthen social learning processes, aligning with Vygotskian perspectives on collaborative knowledge construction.

However, not all game elements contribute equally to learning outcomes. While engagement strongly predicts academic improvement, immersion alone does not necessarily lead to better performance. Instead, appropriately structured challenge appears to be a key driver of learning, both directly and through its effect on engagement (Hamari et al., 2016). This suggests that the effectiveness of game-based learning depends on how well game features promote meaningful cognitive engagement rather than simply increasing interactivity or immersion.

Multiple empirical studies support the academic benefits of both digital and non-digital games. Ke's six-week online math intervention with fourth graders resulted in notable improvements in arithmetic skills and problem-solving, along with reduced math anxiety (Ke, 2008). This reduction can be attributed to scaffolded challenges and repeated exposure in a low-pressure environment. Similarly, Li and Tsai found that third graders who participated in weekly offline math games improved test scores by 15%, largely because the structured, collaborative format encouraged active participation and peer-assisted learning (Li & Tsai, 2013).

Recent experimental research further supports the effectiveness of structured, play-based approaches. Zhiyenbayeva et al. (2026) demonstrated that children engaged in role-playing games significantly outperformed those receiving traditional instruction in

vocabulary acquisition, suggesting that embedding learning within social and narrative contexts enhances retention and understanding. Likewise, studies focusing on cognitive skill development indicate that game-based interventions can strengthen attention, reasoning, and problem-solving abilities, particularly when learners are actively engaged in interactive tasks rather than passive instruction (Doktorová et al., 2026).

Meta-analytic evidence reinforces these findings. Wouters et al., reviewing 39 studies of digital math games, reported an average 11% increase in post-test performance among students using game-based tools (Wouters et al., 2013). In geography learning, Papastergiou found that digital geography games produced 20% higher performance in map-related skills, with improved retention (Papastergiou, 2009). Offline geography games show similar benefits: Charsky and Mims observed increased spatial reasoning and content mastery among students using geography board games (Charsky & Mims, 2008). In a related study, Sung and Hwang reported an 18% improvement in geography knowledge with third graders using online map-based games. Across studies, academic gains typically range from 10–20%, demonstrating consistent benefits for game-based learning in mathematics and geography (Arenas-Gaitán et al., 2018).

Student Engagement and Game-Based Learning

Student engagement is a key predictor of academic achievement and includes behavioural, emotional, and cognitive components (Fredricks, 2014). Within a self-determination framework, engagement is enhanced when learning environments satisfy learners' psychological needs. Digital games enhance engagement through immersive visuals, interactive tasks, and reward systems that encourage persistence and autonomy (Hamari et al., 2014). These design features align with motivational theories emphasizing competence, relevance, and enjoyment (Chen & Tu, 2021). For example, digital game environments such as Minecraft not only capture attention through visual and interactive elements but also sustain engagement by allowing learners to make meaningful choices, experiment with strategies, and receive immediate feedback. This autonomy-supportive structure contributes to deeper cognitive involvement and sustained motivation (Tangkui & Keong, 2023).

Non-digital games also foster engagement, particularly by promoting social interaction and teamwork. Russo et al. found that collaborative offline games strengthen peer communication and build a sense of shared purpose in early learners (Russo et al., 2024). Additionally, non-digital games remain essential for students with limited access to technology, ensuring equitable opportunities for participation and learning (Hwang & Wu, 2014). However, offline games may lack the adaptive difficulty and immediate feedback offered by digital platforms, which can limit individualized learning (Kalmpourtzis, 2018).

Several studies highlight strong engagement outcomes in game-based math and geography instruction. Kebritchi, Hirumi, and Bai reported that fifth graders using both digital and non-digital games demonstrated higher engagement and sustained focus compared to traditional instruction (Kebritchi et al., 2010). De Grove et al. found that collaborative offline games produced high motivation among students in grades 2–5, particularly in group-based activity formats (Pearcy, 2012). Plass, Homer, and Kinzer

documented that digital game-based learning increases sustained attention in early elementary students, with reward systems contributing to deeper cognitive involvement (Plass et al., 2015). These findings show that both digital and non-digital games support engagement in complementary ways. Together, these findings indicate that digital tools primarily enhance cognitive and individual engagement, while non-digital formats strengthen social and behavioural engagement.

Comparative Impact of Digital and Non-Digital Games

Comparative studies reveal that both digital and non-digital educational games offer meaningful benefits, though their strengths differ in important ways. Digital games excel in providing adaptive learning, immediate feedback, and visually rich representations of concepts. Non-digital games, in contrast, support communication skills, social interaction, and physical engagement (Hamari et al., 2014; Russo et al., 2024). From a theoretical lens, digital games tend to emphasize autonomy and competence, whereas non-digital games more directly foster relatedness through collaborative interaction. The degree to which each format improves learning depends on the subject area, age level, and implementation context.

Across studies, game-based interventions consistently yield academic improvements of 11–20% (Ke, 2008; Li & Tsai, 2013). Geography studies show 15–20% gains in spatial skills and content knowledge (Papastergiou, 2009; Sung & Hwang, 2018). Engagement metrics—including surveys, observational checklists, and teacher evaluations—also indicate increased motivation, reduced anxiety, and stronger persistence in game-based learning environments.

Overall, the evidence suggests that integrating both digital and non-digital games provides a balanced approach to instruction. From a motivational perspective, game-based learning supports key psychological needs that enhance student engagement and learning. Combining both formats maximizes learning opportunities by offering adaptability through digital tools and social interaction through non-digital games. This integrated approach aligns with recent empirical findings that recommend blending technological and hands-on strategies to optimize both engagement and academic outcomes in early education contexts.

Purpose of the Study

The purpose of this quasi-experimental study is to examine differences in academic achievement and student engagement associated with digital (online) and non-digital (offline) educational games among young learners. The research focuses on two Grade 1 classes (N = 50) at a public elementary school, with an emphasis on mathematics and geography as foundational subjects in early childhood education. Within this setting, students participated in one of two instructional conditions: an online game group using interactive digital applications with dynamic visuals and immediate feedback, and an offline game group using hands-on board and card games that emphasize social interaction, tactile exploration, and physical engagement. Academic outcomes were measured through pre- and post-tests in mathematics and geography, while engagement was assessed using observation checklists (attendance, participation, and task

completion) and student motivation surveys. Demographic information, including socio-economic status, Individualize Education Plan (IEP) status, and English Language Learner (ELL) status, was also collected to explore how learner characteristics may be associated with engagement and academic outcomes across instructional formats. Together, these measures clarify the overlapping and distinct ways in which online and offline game-based learning may support engagement and learning in early primary classrooms.

Significance of the Study

This study addresses a gap in existing literature by providing a classroom-based comparison of digital (online) and non-digital (offline) educational games with Grade 1 students in mathematics and geography. While many previous studies examine either online or offline games in isolation, fewer investigate how these formats function side by side under similar instructional conditions using both academic and engagement measures. By combining pre- and post-test data, engagement and motivation scales, classroom observation, and demographic information such as socio-economic status, IEP status, and ELL status, this study offers nuanced evidence of how game-based learning operates in an authentic early primary classroom context. The findings suggest that both online and offline game formats are associated with positive academic and engagement-related outcomes, with modest differences across domains and substantial overlap in student gains. These insights can inform educators and policymakers as they consider how to balance digital and non-digital game-based approaches to support learning, engagement, and equitable access to meaningful educational experiences in foundational subjects.

Research Questions

This study is guided by one primary research question, followed by sub-questions that specify the key areas of comparison.

Primary Research Question

1. How do digital (online) and non-digital (offline) educational games differ in their associations with academic achievement and student engagement among Grade 1 learners during mathematics and geography lessons?

Sub-Questions

1. How do levels of engagement and motivation differ between Grade 1 students using online educational games and those using offline games in mathematics and geography?

2. How do academic outcomes in mathematics and geography differ between Grade 1 students using online educational games and those using offline games?

3. How do demographic factors—particularly socio-economic background, IEP status, and ELL status—shape Grade 1 students' engagement and academic outcomes when participating in online and offline game-based learning?

METHOD

Study Population

The study took place at Government Girls High School Maira Kalan, Rawalpindi, Pakistan, a public school that serves students from prekindergarten through Grade 10. The target population for this research consisted of two intact Grade 1 classes. Each class included 25 students, resulting in a total sample of 50 participants. These intact classes were treated as non-equivalent groups, which is a common limitation of quasi-experimental designs due to the absence of random assignment. The classes represented a mix of socio-economic and linguistic backgrounds, which was important for examining how digital and non-digital educational games function across diverse learner profiles.

Information on socio-economic status, IEP status, and ELL status was obtained from school records and parent questionnaires to provide contextual data for interpreting learning outcomes. All students participated only after voluntary informed consent was obtained from parents or guardians, as documented in the permission letters contained in the appendices of the research report. Participation was voluntary and did not affect students' academic standing or school relationships.

Game-Based Learning Tools

The intervention focused on the use of educational games in mathematics and geography, implemented in two formats: offline (non-digital) games and online (digital) games. Both formats were selected to align with constructivist principles that emphasize active engagement, exploration, and scaffolded practice.

For mathematics in the offline condition, a collaborative card-based arithmetic game was used to strengthen basic addition and subtraction skills. Students worked in small groups, drawing and solving equation cards, comparing answers, and supporting each other's problem-solving. This structure encouraged peer interaction, verbal reasoning, and repeated practice of core number facts.

For geography in the offline condition, a board game was used that introduced map features, spatial relationships, and recognizable landmarks. Students moved pieces across a map layout and responded to prompts on illustrated cards. The tactile nature of the materials supported hands-on learning and helped young children connect abstract geographic concepts with concrete visual and physical experiences.

In the online condition, mathematics instruction incorporated an interactive arithmetic application that presented age-appropriate problems through gamified challenges. The app included animated characters, visual supports, and reward systems such as points or badges. Immediate feedback on answers allowed students to correct errors in real time and provided additional practice when needed.

For geography in the online condition, students used a digital exploration game that simulated virtual "world tours." Through interactive map navigation and landmark recognition tasks, learners explored continents, countries, and key places. Animated scenarios and visual cues were intended to make spatial concepts more engaging and

accessible for Grade 1 students. Together, these tools ensured that both groups were exposed to game-based learning, with the main difference being the digital versus non-digital format.

Study Design and Procedure

The study employed a quasi-experimental pretest–posttest design to compare the impact of online and offline educational games on academic achievement and engagement in Grade 1 mathematics and geography. The two existing classes were assigned to different game formats: one class used online educational games (digital condition), and the other used offline games (non-digital condition). In both cases, the games were integrated into regular classroom instruction rather than being treated as separate enrichment activities.

To ensure fidelity of implementation, standardized lesson plans were used across both groups, and the teacher received prior orientation on delivering both digital and non-digital game-based activities. Classroom sessions were periodically monitored by the researchers to maintain consistency in instructional delivery throughout the six-week intervention

The intervention spanned six weeks. Students participated in weekly sessions of approximately two hours, with three weeks devoted to mathematics and three weeks devoted to geography. This schedule ensured that both groups received comparable instructional time in each subject area while experiencing consistent exposure to their assigned game format.

Before the intervention began, all students completed pretests in mathematics and geography to establish baseline academic performance. Baseline measures of engagement and motivation were also collected through surveys and classroom observations. During the six-week intervention, teachers implemented the assigned games during designated lesson times, and the researchers or trained observers used structured checklists to record attendance, participation, and task completion. At the end of the intervention, posttests in mathematics and geography were administered, along with follow-up engagement and motivation surveys. Teacher feedback and informal observations were also gathered to provide a richer qualitative understanding of how the games functioned within the classroom context.

Instruments

Multiple instruments were used to capture both academic and engagement-related outcomes. Academic achievement in mathematics and geography was measured through grade-appropriate pre-, and post-tests aligned with the curriculum. These tests assessed basic arithmetic operations, map-reading skills, landmark identification, and related content knowledge.

The instruments used in this study were adapted from existing educational assessments and reviewed by subject experts to ensure content validity and age appropriateness. In addition, a pilot check was conducted with a small group of Grade 1 students to confirm clarity, comprehension, and suitability of the instruments.

Student engagement and motivation were assessed through a combination of observation and self-report. A structured classroom observation checklist was used during game sessions to document attendance, visible participation in activities, and completion of assigned tasks. In addition, Likert-type student surveys were used to measure perceived enjoyment, motivation, and sense of learning during game-based lessons.

Although formal reliability coefficients such as Cronbach's alpha were not calculated, the engagement and motivation instruments were developed based on established formats in prior research and reviewed by educators to ensure clarity, consistency, and age appropriateness for Grade 1 learners.

Qualitative data were collected through teacher feedback and semi-structured interviews. Teachers commented on student behavior, classroom dynamics, ease of integrating the games into lessons, and perceived benefits and challenges of each format. Demographic data, including socio-economic status, IEP status, and ELL status, were collected from school records and parent questionnaires to support subgroup analyses and interpretation of patterns in the data.

Ethical Considerations

Ethical principles guided every stage of the research. Parents and guardians received a detailed permission letter describing the purpose, procedures, voluntary nature, and confidentiality measures of the study. Only students with signed consent forms were included. To protect privacy, student identities were replaced with codes in all data files, and records were stored securely in password-protected formats.

The activities themselves were designed to be low-risk and integrated into standard classroom practice. Educational games were aligned with curriculum goals and did not replace essential instruction. Students were informed that their participation in the study would not affect their grades or standing in school and that they could withdraw at any time. These measures were consistent with general principles of ethical research with children, including respect, beneficence, and protection from harm.

Data Analysis

Data analysis followed a mixed-method approach. Quantitative data from pre- and post-tests in mathematics and geography were first examined using descriptive statistics to summarize overall performance patterns. Paired comparisons were used to evaluate changes within each group from pretest to posttest, and between-group comparisons were conducted to examine differences in posttest scores between the online and offline game conditions. Effect sizes were calculated to assess the practical significance of any observed differences.

Engagement and motivation survey scores, along with observation data on attendance, participation, and task completion, were analyzed in a similar way, with descriptive and inferential statistics used to compare the two groups. Correlation analyses explored relationships between academic outcomes and engagement measures, as well as the

potential influence of demographic variables such as socio-economic status, IEP status, and ELL status.

Qualitative data from teacher feedback and observation notes were analyzed thematically. Responses were read repeatedly, coded for recurring ideas such as enjoyment, collaboration, challenges with technology, and classroom management, and then grouped into broader themes. These qualitative findings were used to contextualize and interpret the quantitative results, offering a more comprehensive understanding of how digital and non-digital games functioned in the Grade 1 classroom setting.

FINDINGS

The results of the study are presented below, focusing on changes in academic performance and engagement across the two instructional conditions. Analyses examine pre- to post-intervention gains in mathematics and geography, as well as engagement and motivation over the six-week intervention. Results are reported using summary statistics, visualizations, and correlational analyses to capture overall trends and variability in student outcomes.

Academic and Engagement Outcomes

Across both instructional conditions, students demonstrated positive gains in mathematics, geography, engagement, and motivation following the six-week intervention. Examination of baseline performance indicated no meaningful initial advantage for either group, supporting the appropriateness of comparing learning gains across instructional formats.

Average improvement percentages for each outcome are presented in Table 1. Both online and offline groups showed improvement across all domains. The online group demonstrated slightly higher percentages of average improvement in mathematics, geography, engagement, and motivation; however, the magnitude of improvement across groups fell within a comparable range.

Table 1
Average improvement percentages

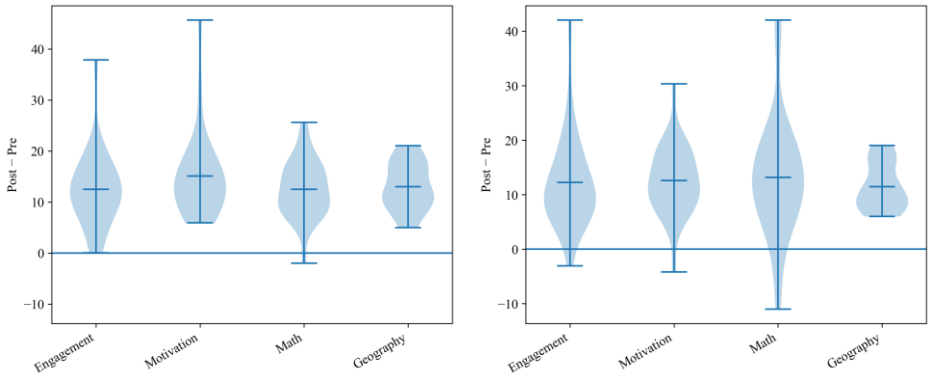
%	Math	Geography	Engagement	Motivation
Offline	19.02	17.44	13.69	17.64
Online	24.29	18.41	15.96	19.91

To assess whether these differences were statistically meaningful, independent t-tests were conducted on post-intervention scores for engagement, motivation, mathematics, and geography. The results are summarized in Table 2. None of the group comparisons reached statistical significance, and effect sizes were small across all outcomes, indicating minimal practical differences between instructional formats.

Table 2
Independent t-test results

Parameter	Post Engagement	Post Motivation	Post Math	Post Geography
t-statistics	0.4111	0.4387	0.5783	-0.6345
p-value	0.6828	0.6628	0.5657	0.5288
Effect Sizes (Cohen's d)	0.1163	0.1241	0.1636	-0.1795

To visualize the distribution and variability of student gains, Figure 1 presents violin plots of gain scores for engagement, motivation, mathematics, and geography. The violin plots show substantial overlap between online and offline groups across all outcomes, with gain distributions predominantly above zero, indicating improvement for most students. The width and shape of the distributions highlight variability in individual responses, particularly for engagement and mathematics.



Online game-based instruction. Offline game-based instruction.

Figure 1
Violin plots showing the distribution of gain scores (post–pre)

Relationships Among Engagement, Motivation, and Academic Outcomes

To explore relationships among learning domains, Pearson correlation coefficients were calculated using gain scores for engagement, motivation, mathematics, and geography. Correlation matrices for the online and offline groups are presented in Figure 2. Across both instructional conditions, correlations among gain scores were weak to moderate. Engagement gains showed limited association with academic gains, while motivation gains demonstrated small positive relationships with geography gains. Overall, these findings suggest that improvements across domains were related but not strongly coupled.

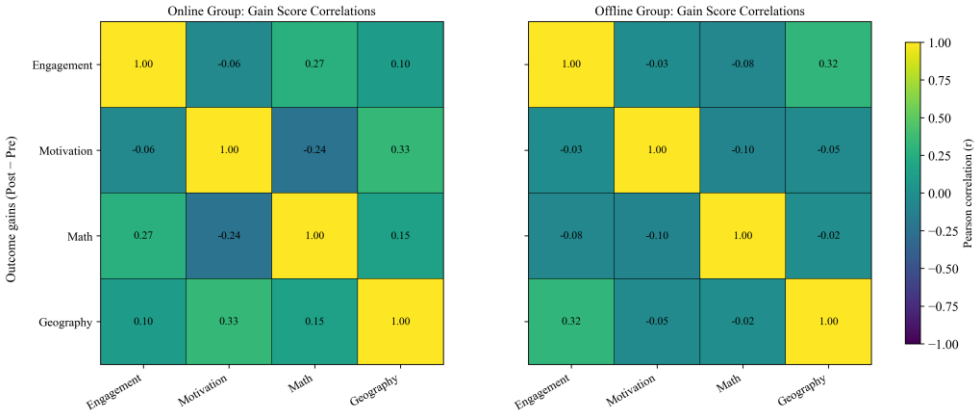


Figure 2.
Correlation matrices showing relationships among gain scores (post–pre) for online (a) and offline (b) game-based instruction

Figure 3 presents composite academic and engagement gains across socio-economic status (SES) groups. Median gains are positive for all SES categories, indicating improvement regardless of background. Although slight differences in median are observable, the substantial overlap in gain distributions suggests no consistent SES-related pattern in either academic or engagement outcomes.

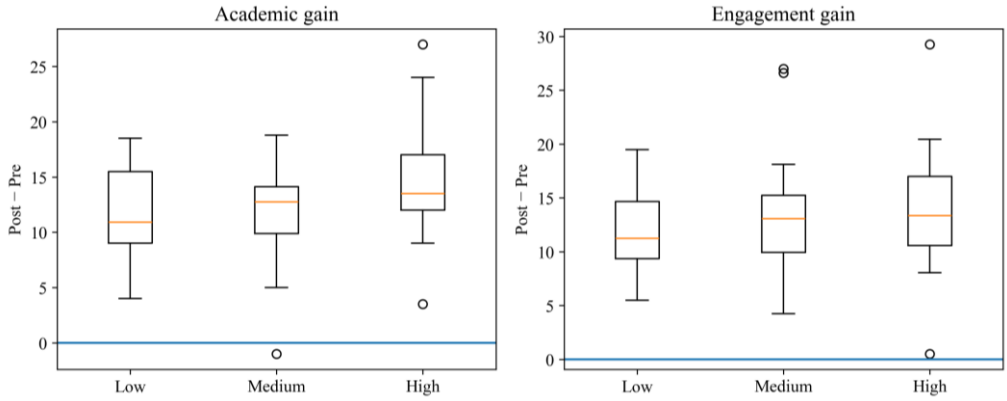


Figure 3
Composite academic (a) and engagement (b) gain scores (post–pre) across SES groups

Figure 4 displays composite gains by IEP status. Both students with and without IEPs demonstrated positive academic and engagement gains following the intervention. While variability is somewhat greater among students with IEPs, the overlapping distributions indicate comparable overall patterns of improvement across groups.

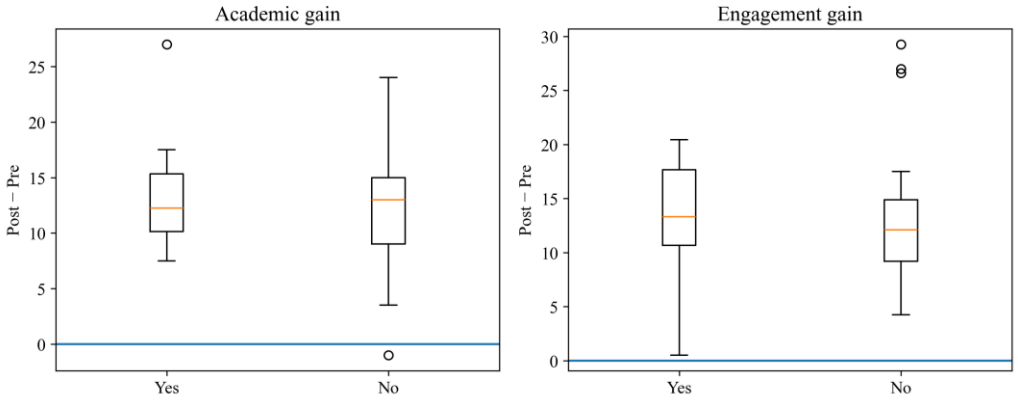


Figure 4
Boxplots of composite academic (a) and engagement (b) gain scores (post–pre) for students with and without IEPs

As shown in Figure 5, both ELL and non-ELL students experienced positive academic and engagement gains. Median gains are similar across groups, and the overlapping distributions suggest that language status did not systematically influence students' responses to game-based instruction.

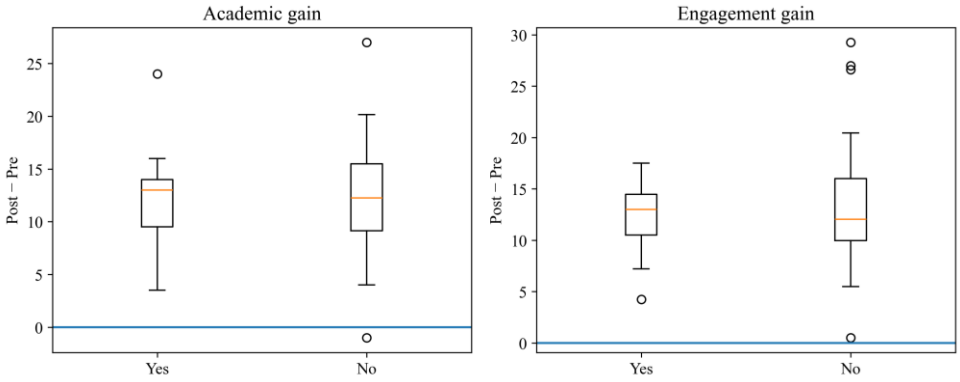


Figure 5
Composite academic (a) and engagement (b) gain scores (post–pre) by ELL status

Taken together, the demographic analyses indicate that composite academic and engagement gains were broadly similar across SES, IEP, and ELL groups. Although some variability is evident within each category, no consistent demographic pattern emerged. These findings suggest that both academic and engagement benefits of game-based learning were experienced across diverse learner backgrounds.

RESULTS

The results of the study provide a clear picture of how digital and non-digital educational games influenced Grade 1 students' academic performance and engagement during mathematics and geography lessons. Analyses of pre- and post-test scores, improvement percentages, engagement indicators, statistical comparisons, and correlation patterns yield the following key findings:

Academic Performance

1. Both groups showed meaningful improvement in mathematics and geography scores over the six-week intervention.

2. Students using online games demonstrated slightly higher percentage gains, but these differences were small and not statistically significant.

3. Independent t-tests confirmed no significant differences between the online and offline groups on post-test scores, suggesting both methods were equally effective in supporting academic learning.

Engagement and Motivation

1. Engagement levels remained high across the intervention in both groups, with students showing consistent attendance, participation, and task completion.

2. The offline group exhibited marginally higher participation and task-completion rates, likely due to the collaborative and tactile nature of non-digital games.

3. Motivation scores increased in both groups from pre- to post-test, indicating that game-based activities were successful in sustaining learner interest and emotional involvement.

Statistical and Correlational Patterns

1. Effect sizes for all academic and engagement measures were small, reinforcing the similarity of outcomes across formats.

2. Correlational analyses revealed weak relationships between engagement indicators and academic achievement, suggesting that high engagement does not necessarily predict larger academic gains.

3. These patterns imply that while games support participation and enthusiasm, academic improvement may depend on additional factors such as prior knowledge, lesson pacing, and individual learning needs.

Overall, the findings indicate that both digital and non-digital educational games are effective instructional tools for Grade 1 mathematics and geography, producing comparable outcomes in achievement, engagement, and motivation.

DISCUSSION

The present study aimed to examine the comparative impact of digital and non-digital educational games on Grade 1 students' academic achievement and engagement in mathematics and geography. While both instructional formats resulted in measurable improvements, the absence of statistically significant differences between groups provides important insights into how game-based learning functions in early education contexts.

One notable finding is that although the online group demonstrated slightly higher improvement percentages, these differences were not statistically significant. This outcome may be explained by the fact that both digital and non-digital games were designed around similar pedagogical principles, including active participation, repetition, and feedback. In digital environments, immediate feedback and adaptive progression may have supported students' sense of competence and autonomy. However, non-digital games offered equally meaningful learning opportunities through peer interaction, discussion, and hands-on engagement, which may have strengthened understanding through social learning processes. As a result, both formats provided comparable cognitive support, leading to similar academic outcomes.

This finding aligns with prior research suggesting that the effectiveness of game-based learning depends more on instructional design than on the medium itself (Hamari et al., 2014; Wouters et al., 2013). While digital tools offer technological advantages, such as instant feedback and visual scaffolding, non-digital approaches can achieve similar outcomes by promoting collaboration and verbal reasoning (Hamari et al., 2014). Therefore, the similarity in results across groups suggests that well-structured learning experiences—rather than the format alone—play a critical role in supporting student achievement.

Another important finding is the weak correlation between engagement indicators and academic achievement. Although students in both groups demonstrated high levels of participation, attendance, and task completion, these factors were only weakly associated with learning gains. One possible explanation is that the engagement measures used in this study primarily captured observable behaviours rather than deeper cognitive engagement. Students may have been actively participating in activities without fully internalizing the targeted academic concepts. Additionally, academic improvement in early learners may depend on factors such as prior knowledge, cognitive readiness, and instructional pacing, which are not fully captured by surface-level engagement indicators.

The demographic analyses further revealed that students from different socio-economic backgrounds, language profiles, and IEP statuses experienced similar levels of improvement. This finding is particularly important from an equity perspective, as it suggests that both digital and non-digital game-based approaches can support diverse learners effectively. The lack of significant variation across demographic groups indicates that game-based learning may provide inclusive instructional opportunities that accommodate a wide range of learning needs.

Overall, the findings highlight that both digital and non-digital educational games are effective tools for supporting learning and engagement in early-grade classrooms. Rather than viewing these formats as competing approaches, the results suggest that they can be used complementarily to maximize learning outcomes. Digital tools may be particularly useful for individualized practice and feedback, while non-digital games can foster collaboration and social interaction. Integrating both approaches may therefore provide the most balanced and effective learning environment.

CONCLUSION

This study examined the impact of digital and non-digital educational games on Grade 1 students' academic achievement and engagement in mathematics and geography. The results demonstrate that both instructional formats supported measurable improvements in students' content knowledge, engagement, and motivation. Although the online group exhibited slightly higher percentages, these differences were not statistically significant, indicating that digital and non-digital games are equally viable options for early-grade instruction.

The engagement data indicate consistent participation and task completion across both instructional formats. While non-digital games fostered slightly more collaborative interactions, digital games maintained individual engagement effectively through interactive features and immediate feedback. The weak relationship between engagement and academic gains suggests that learning outcomes are influenced by multiple instructional factors. Teachers may benefit from using digital games for individualized skill practice, particularly where immediate feedback is advantageous, while incorporating non-digital games to promote collaboration, discussion, and conceptual understanding through peer interaction.

Taken together, these findings highlight the instructional value of integrating both digital and hands-on games in Grade 1 classrooms. Both tools can enhance learning experiences, sustain motivation, and support the development of foundational mathematics and geography skills. Game-based learning, when intentionally embedded into lesson plans, offers an accessible and engaging approach that benefits young learners across diverse classroom contexts.

Future research should explore more detailed measures of engagement and extend the duration of interventions to better understand how game-based learning influences long-term academic development in early education.

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