Game Nexus

The Effect of Educational Computer Games on Students' Academic Engagement and Academic Self-Efficacy

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ABSTRACT

This study aimed to examine the effect of educational computer games on students' academic engagement and academic self-efficacy. The present study was a quasi-experimental study conducted using a pretest–posttest design with a control group. Accordingly, the participants were assigned to two groups, namely the experimental and control groups. The experimental group received instruction through educational computer games, whereas the control group received no instruction. The study population included all students in the second cycle of secondary education. From among these students, 30 individuals were selected as the sample based on the inclusion and exclusion criteria using convenience sampling, and they were randomly assigned to the experimental and control groups. The instruments used in the present study included the Academic Engagement Scale developed by Pintrich et al. (1991) and the Academic Self-Efficacy Scale developed by Jinks and Morgan (1999). Data analysis in the present study was conducted using SPSS version 26 at both descriptive and inferential levels. At the descriptive level, mean, standard deviation, frequency, and percentage indices were used, while at the inferential level, analysis of covariance was applied. The obtained F value was significant for both variables at the 0.05 level. Therefore, the null hypothesis was rejected, and the research hypothesis was confirmed. Considering the higher mean scores of the experimental group in the posttest phase for academic engagement and academic self-efficacy, it can be concluded that educational computer games have a significant effect on students' academic engagement and academic self-efficacy. The results indicated that educational computer games have a significant effect on students' academic engagement and academic self-efficacy.

Keywords: computer games, educational, academic engagement, academic self-efficacy, students.

Introduction

In contemporary educational systems, the quality of students' learning experiences is increasingly evaluated not only through academic achievement, but also through motivational, cognitive, emotional, and behavioral indicators that reflect how actively learners participate in the educational process. Among these indicators, academic engagement and academic self-efficacy have received substantial attention because they represent two central psychological mechanisms through which students approach learning tasks, persist in the face of difficulty, and regulate their educational performance. Academic engagement refers to the degree of students' involvement in learning activities and is commonly understood as a multidimensional construct that includes behavioral participation, cognitive investment, emotional connection, persistence, and

purposeful interaction with academic tasks. Academic self-efficacy, in turn, refers to students' beliefs about their ability to successfully perform academic tasks, master learning demands, and achieve educational goals. These two constructs are closely related, because students who believe in their academic capabilities are more likely to invest effort, remain engaged, seek help when necessary, and use adaptive learning strategies. Recent models of student functioning have emphasized that academic self-efficacy is associated with higher engagement and lower maladaptive academic behaviors, including procrastination and burnout (1). Therefore, identifying educational approaches that can simultaneously enhance academic engagement and academic self-efficacy is a significant priority for instructional design and educational management.

The importance of academic engagement becomes more evident when learning is viewed as an active, constructive, and self-regulated process rather than a passive reception of information. Engaged students demonstrate higher levels of attention, persistence, motivation, strategy use, and emotional connection with learning environments. Academic engagement also plays an important mediating role in students' academic adjustment and success. For example, the relationship between academic help-seeking and academic adjustment has been shown to operate through academic engagement, suggesting that engaged students are more capable of using available educational resources and adapting to academic expectations (2). Engagement is also strongly connected to motivational and affective dimensions of learning. The affective domain, including students' motivations, attitudes, interest, and emotional responses, is a major component of learning outcomes because it shapes how learners approach academic challenges and whether they maintain participation in demanding educational contexts (3). In this regard, educational interventions that stimulate curiosity, enjoyment, task value, and active participation may improve engagement more effectively than conventional instruction that relies mainly on passive transmission of content.

Academic self-efficacy is another essential construct in educational psychology and learning sciences. It influences students' choices, effort, persistence, resilience, and emotional reactions to academic tasks. Students with stronger academic self-efficacy are more likely to perceive difficult tasks as manageable challenges rather than threats, and they tend to use more adaptive cognitive and metacognitive strategies. Academic self-efficacy is particularly important during adolescence, when students encounter more complex academic demands and must develop stronger independent learning capacities. Research on academic buoyancy has shown that self-efficacy is a key predictor of students' capacity to cope with routine academic difficulties and maintain functioning under educational pressure (4). Similarly, causal modeling among gifted students has indicated that academic self-efficacy plays a mediating role in the relationship between critical thinking and academic buoyancy, highlighting its function as a psychological pathway through which cognitive resources are translated into adaptive academic outcomes (5). These findings suggest that strengthening academic self-efficacy can support students' confidence, persistence, and resilience in learning situations.

Self-efficacy is also closely linked to other adaptive academic resources. Studies have shown that academic self-efficacy mediates the relationship between academic optimism and academic buoyancy, indicating that positive educational expectations may influence students' adaptive functioning through their belief in their own academic competence (6). Other evidence has demonstrated that self-regulation and self-efficacy are associated with academic buoyancy, with academic resilience playing a mediating role in this relationship (7). In addition, the relationship between academic self-efficacy and academic buoyancy has been examined through the mediating role of basic psychological needs, suggesting that students' feelings of competence, autonomy, and relatedness may strengthen the effect of self-efficacy on adaptive academic functioning (8). These findings collectively show that academic self-efficacy is not an isolated belief, but part of a broader motivational system that shapes engagement, resilience, and learning behavior. Accordingly, educational interventions that provide students with successful learning experiences, immediate feedback, autonomy, and opportunities for mastery can be expected to improve academic self-efficacy.

In recent years, educational computer games have become an important instructional tool because they combine learning content with interactive, motivational, and problem-solving activities. Educational computer games are designed to create structured learning environments in which students can practice skills, receive feedback, solve problems, and progress through levels of difficulty. Unlike many traditional instructional methods, game-based learning environments can increase students' active participation by integrating challenge, reward, curiosity, competition, collaboration, and immediate response mechanisms. These characteristics are theoretically compatible with the development of both academic engagement and academic self-efficacy. When students interact with educational games, they often experience a more active role in learning, because they must make decisions, test strategies, correct mistakes, and monitor their progress. Such experiences can increase students' perception of control over learning and provide repeated mastery experiences, which are among the most important sources of self-efficacy. From an instructional management perspective, educational games can also support differentiated learning by allowing students to proceed at an appropriate pace and receive feedback according to their performance.

The growing interest in computer-based educational games is supported by empirical research in different learning domains. Studies have examined the effects of computer-based educational games on creativity and academic engagement, particularly in mathematics education, and have reported that such games can improve learners' involvement in academic activities (9). Other research has compared entertaining and systematic educational computer games and has shown that carefully structured educational games may contribute to students' mathematics achievement and learning experiences (10). Experimental work on elementary mathematics education has also emphasized that educational theories should guide computer game design, because game environments are most effective when their mechanics are aligned with cognitive load, feedback, scaffolding, and instructional goals (11). These findings indicate that the educational value of computer games depends not merely on entertainment, but on their ability to integrate motivational design with pedagogically meaningful content.

Digital game-based learning has also expanded through tablet-based and online environments. Evidence regarding tablet-based digital games has shown that such tools can affect mathematics learning performance, especially when interactive design elements are used to support students' attention and learning practice (12). Systematic review evidence on entertainment video games for academic learning has similarly suggested that digital games can contribute to academic learning when they are appropriately selected, instructionally relevant, and embedded in a structured educational process (13). These findings are important because they show that the effectiveness of video games in educational contexts is not automatic; rather, it depends on the alignment between game content, learning objectives, students' developmental level, and the instructional context. Therefore, when educational computer games are implemented as part of a planned learning intervention, they may create conditions that strengthen both students' engagement in learning and their beliefs about their academic capabilities.

At the same time, the relationship between computer games, digital technologies, and academic outcomes is complex. Some studies have warned that excessive or uncontrolled use of online games can have negative consequences for learning. For example, online game addiction has been associated with reduced academic achievement motivation, with learning engagement serving as a mediating variable (14). Similarly, internet addiction has been linked to academic achievement through the mediating role of adolescents' academic engagement, and classroom achievement norms may influence this relationship (15). These findings indicate that the educational impact of digital games depends on how they are used. Recreational or excessive gaming may undermine academic motivation and engagement, whereas structured educational games may support learning when they are designed and implemented with clear pedagogical objectives. Social factors affecting adolescents' use of computer games also show that gaming behavior can be related to psychosocial health, suggesting that educational systems must distinguish between uncontrolled gaming exposure and guided educational use of game technologies (16). Therefore, the

present study focuses specifically on educational computer games as intentional learning tools, not on unsupervised recreational gaming.

The theoretical justification for using educational games is also related to motivation, self-regulated learning, and strategic adaptation. Game-based environments can provide feedback loops, progressive challenges, and opportunities for repeated practice, all of which may strengthen students' sense of competence. In organizational and management literature, dynamic competencies and meta-learning emphasize the importance of adaptation, learning from experience, and adjusting strategies to changing contexts (17). Although this concept originates in management studies, it can also be applied to educational settings in which learners must develop adaptive learning competencies. Educational computer games can create micro-environments for meta-learning because students observe the consequences of their choices, revise strategies, and gradually improve performance. In this sense, game-based learning can be interpreted not only as a technological intervention, but also as a structured system for managing learning processes, feedback, motivation, and performance improvement.

Academic engagement during digital and virtual learning contexts has become especially important in recent educational conditions. During the COVID-19 period, research on teaching-learning processes in virtual environments emphasized that teachers' skills and instructional strategies could predict students' academic engagement (18). Similarly, studies conducted in virtual educational spaces have examined the effects of diagnostic, formative, and final assessment on learning and academic engagement, suggesting that instructional monitoring and feedback mechanisms can shape students' involvement in learning (19). Educational computer games may provide an effective format for such monitoring and feedback because they allow learners to receive immediate information about their performance and progress. These features can reduce passivity in digital learning environments and transform students from recipients of instruction into active participants in the learning process. Consequently, educational games may be especially valuable in contexts where maintaining attention, motivation, and engagement is challenging.

The role of assessment and feedback is also central to academic self-efficacy. Academic self-efficacy is influenced by students' interpretation of their academic performance and by the feedback they receive from the learning environment (20). Educational games can offer immediate corrective feedback, reinforcement, and visible indicators of progress, which may help students build more accurate and positive beliefs about their academic abilities. In addition, research on multidimensional perceived self-efficacy among adolescents has shown that self-efficacy is a measurable and developmentally meaningful construct across cultural contexts (21). This is particularly important for secondary school students, because their self-efficacy beliefs are shaped by repeated learning experiences, social comparison, task success, and perceived competence. By creating opportunities for success and gradual mastery, educational computer games may support the development of academic self-efficacy in a way that traditional instruction may not always achieve.

Motivation and engagement are also associated with academic achievement across educational levels. Research among college students has shown that motivation and engagement are related to academic achievement, indicating that students' psychological involvement in learning is a critical factor in educational performance (22). Although the present study focuses on secondary school students rather than college students, the same theoretical logic applies: when learners are motivated, engaged, and confident in their abilities, they are more likely to participate actively and persist in learning. Educational computer games may influence these processes by increasing task attractiveness, reducing fear of failure, and transforming learning activities into interactive challenges. This is consistent with the broader educational view that learning environments should support not only content acquisition but also motivation, self-regulation, and positive academic beliefs.

Despite the growing body of research on educational games, academic engagement, and academic self-efficacy, several gaps remain. Many studies have focused on achievement outcomes, creativity, or mathematics performance, while fewer have

examined motivational and self-belief outcomes simultaneously in secondary school students. Furthermore, some evidence emphasizes the risks of excessive digital gaming, whereas other studies highlight the benefits of structured educational games. This distinction indicates the need for empirical studies that evaluate educational computer games under controlled instructional conditions. The present study addresses this need by examining whether educational computer games can improve two important student outcomes: academic engagement and academic self-efficacy. By focusing on a quasi-experimental pretest–posttest design with a control group, the study seeks to provide evidence on the effectiveness of game-based educational intervention in enhancing students' motivational and self-efficacy-related academic functioning.

The aim of the present study was to examine the effect of educational computer games on academic engagement and academic self-efficacy among secondary school students.

Methods and Materials

The present study employed a quasi-experimental research design with a pretest–posttest structure and a control group. In this design, the participants were assigned to two groups, including an experimental group and a control group. The experimental group received instruction through educational computer games, whereas the control group received no educational intervention during the implementation period. The statistical population of the study consisted of all students enrolled in the second cycle of secondary education. From this population, 30 students were selected as the research sample based on the inclusion and exclusion criteria using convenience sampling. The selected participants were then randomly assigned to the experimental and control groups, with 15 students in each group. Before the intervention, both groups completed the pretest measures of academic engagement and academic self-efficacy. After the educational intervention was completed, the same instruments were administered again as the posttest to both groups.

Academic Engagement Questionnaire. Students' academic engagement was assessed using items derived from the Motivated Strategies for Learning Questionnaire developed by Pintrich et al. (1991). The original scale consists of 80 items and includes five different subscales. In accordance with the purpose of the present study, which was to measure academic engagement, the subscales of task value, cognitive and metacognitive strategies, effort and persistence, and help-seeking were extracted from the original questionnaire. Accordingly, 36 items from the original questionnaire were refined and used in this study. The questionnaire is scored on a five-point Likert scale ranging from "strongly disagree" to "strongly agree." Except for Item 21, which is reverse-scored, all items are scored from 1 to 5. In this instrument, Items 1 to 6 assess task value, Items 7 to 10 assess effort and persistence in tasks, Items 11 to 31 assess cognitive and metacognitive strategies, and Items 32 to 36 assess help-seeking. Lavasani et al. (2009) reported Cronbach's alpha coefficients of 0.72 for effort, 0.59 for help-seeking, 0.82 for cognitive strategies, 0.69 for metacognitive strategies, and 0.86 for task value. Kordi (2016) reported an overall Cronbach's alpha coefficient of 0.90 for this instrument and alpha coefficients of 0.73, 0.85, and 0.80 for behavioral engagement, cognitive engagement, and emotional engagement, respectively. In another study, Jadidi (2019) reported a Cronbach's alpha coefficient of 0.89 for the questionnaire.

Academic Self-Efficacy Questionnaire. Academic self-efficacy was measured using the standard Student Self-Efficacy Questionnaire developed by Jinks and Morgan (1999). This instrument consists of 30 items and includes three subscales: talent, effort, and context. Items 1 to 10 are related to talent, Items 11 to 20 are related to effort, and Items 21 to 30 are related to context. The questionnaire is designed based on a Likert-type response format. According to the scoring procedure, Items 1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 17, 18, 21, 24, 25, 26, 28, 29, and 30 are scored directly, whereas Items 4, 5, 15, 16, 19, 20, 22, and 23 are reverse-scored. The developers of the instrument reported a reliability coefficient of 0.82 for the total scale and reliability coefficients of 0.78, 0.66, and 0.70 for the talent, effort, and context subscales, respectively. In the study by

Abdolinejad (2022), the content validity of the questionnaire was confirmed, and its reliability was reported as 0.91 using Cronbach's alpha.

The implementation procedure began after the selection of the sample. The selected students were invited to participate in an orientation session, during which all stages of the research process were explained to them. The participants were informed that their information would remain confidential and anonymous. After obtaining the necessary cooperation and administering the pretest to the participants in both groups, the educational sessions were conducted for the experimental group using educational computer games. These sessions were designed to provide learning experiences through game-based educational activities and to enhance students' active involvement in learning tasks. The control group did not receive any educational intervention during this period. After the completion of the intervention sessions, the academic engagement and academic self-efficacy questionnaires were administered again to the participants in both the experimental and control groups. The collected data were then prepared for statistical analysis.

Data analysis was conducted using SPSS version 26 at both descriptive and inferential levels. At the descriptive level, mean, standard deviation, frequency, and percentage were used to describe the demographic and research variables. At the inferential level, analysis of covariance was used to examine the effect of educational computer games on students' academic engagement and academic self-efficacy while controlling for pretest scores. The significance level for all statistical tests was set at 0.05.

Findings and Results

The demographic findings showed that the participants were distributed across the 10th, 11th, and 12th grades in both the experimental and control groups. In the experimental group, the highest number of students was in the 10th grade, with 6 students (40.00%), followed by 5 students in the 11th grade (33.30%) and 4 students in the 12th grade (26.70%). In the control group, the highest number of students was in the 11th grade, with 7 students (46.60%), followed by 5 students in the 10th grade (33.30%) and 3 students in the 12th grade (20.00%). Overall, both groups consisted of 15 students, and the total sample included 30 students.

Table 1. Descriptive Statistics of the Dependent Variables by Group and Test Phase

Variable	Group	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD
Academic engagement	Experimental	15	48.00	2.26	168.93	4.52
Academic engagement	Control	15	49.33	3.10	49.93	3.41
Academic self-efficacy	Experimental	15	38.06	2.49	141.73	3.91
Academic self-efficacy	Control	15	39.00	4.48	39.40	4.62

As shown in Table 1, the mean scores of academic engagement and academic self-efficacy increased more substantially in the experimental group than in the control group from the pretest to the posttest phase. The mean score of academic engagement in the experimental group increased from 48.00 in the pretest to 168.93 in the posttest, whereas the control group showed only a slight change from 49.33 to 49.93. Similarly, the mean score of academic self-efficacy in the experimental group increased from 38.06 in the pretest to 141.73 in the posttest, while the control group showed only a minor change from 39.00 to 39.40. These descriptive findings indicate that students who received instruction through educational computer games demonstrated greater improvement in both academic engagement and academic self-efficacy compared with students in the control group.

Before conducting the analysis of covariance, the statistical assumptions were examined. The homogeneity of covariance matrices was assessed using Box's M test. The results showed that Box's M was 6.646, with $F = 2.044$, $df1 = 3$, $df2 = 141120$, and $p = .105$. Since the significance level was greater than the conservative criterion of .01, the assumption of homogeneity of covariance matrices was confirmed. The homogeneity of variances was examined using Levene's test. The results showed that

Levene's test was not significant at the .01 level for academic engagement, $F(1, 28) = 4.282$, $p = .048$, or academic self-efficacy, $F(1, 28) = 4.556$, $p = .041$. Therefore, the assumption of homogeneity of variances was also considered acceptable, and the data met the required assumptions for conducting the analysis of covariance.

Table 2. Analysis of Covariance for Comparing Academic Engagement and Academic Self-Efficacy Between the Experimental and Control Groups at Posttest

Variable	Source	Sum of Squares	df	Mean Square	F	p	η^2
Academic engagement	Group	96110.512	1	96110.512	7364.485	.001	.996
Academic engagement	Error	339.314	26	13.051			
Academic engagement	Total	465927.000	30				
Academic self-efficacy	Group	71843.332	1	71843.332	9404.524	.001	.997
Academic self-efficacy	Error	198.620	26	7.639			
Academic self-efficacy	Total	325125.000	30				

As presented in Table 2, the analysis of covariance showed a statistically significant difference between the experimental and control groups in posttest academic engagement after controlling for pretest scores, $F(1, 26) = 7364.485$, $p = .001$, $\eta^2 = .996$. The results also indicated a statistically significant difference between the experimental and control groups in posttest academic self-efficacy after controlling for pretest scores, $F(1, 26) = 9404.524$, $p = .001$, $\eta^2 = .997$. Therefore, the null hypothesis was rejected, and the research hypothesis was supported. Considering the higher posttest mean scores of the experimental group compared with the control group, it can be concluded that educational computer games had a significant positive effect on students' academic engagement and academic self-efficacy.

Discussion and Conclusion

The present study aimed to examine the effect of educational computer games on students' academic engagement and academic self-efficacy. The findings showed that students in the experimental group, who received instruction through educational computer games, demonstrated a marked increase in academic engagement and academic self-efficacy from pretest to posttest, whereas the control group showed only minimal changes. The results of the analysis of covariance confirmed that the difference between the experimental and control groups was statistically significant for both dependent variables. Therefore, the research hypothesis was supported, and it can be stated that educational computer games had a significant positive effect on students' academic engagement and academic self-efficacy. These findings suggest that when computer games are designed and implemented for educational purposes, they can function as an effective instructional strategy for improving students' motivational involvement in learning and strengthening their beliefs about their academic capabilities.

The significant effect of educational computer games on academic engagement can be explained by the interactive, challenging, and feedback-oriented nature of game-based learning environments. Academic engagement is not limited to students' physical presence in the classroom; rather, it includes behavioral participation, emotional involvement, cognitive investment, persistence, and active use of learning strategies. Educational computer games can enhance these dimensions by transforming learning tasks into structured activities that require students to make decisions, solve problems, receive immediate feedback, and continue progressing through different levels of difficulty. In this regard, the findings are consistent with the study of Afzali et al., who showed that computer-based educational games can improve creativity and academic engagement among elementary students in mathematics (9). The present findings also support previous evidence indicating that academic engagement plays a central role in students' adjustment and learning processes, particularly when students are actively involved in help-seeking, strategy use, and task persistence (2). Therefore, the improvement observed in academic engagement may be

attributed to the capacity of educational games to create an active learning environment in which students experience participation, curiosity, task value, and sustained attention.

The results are also aligned with studies emphasizing the motivational and affective foundations of learning. Kirk emphasized that students' motivations, attitudes, interests, and emotional responses are important components of the affective domain and play a decisive role in learning outcomes (3). Educational computer games may stimulate this affective domain by making learning more enjoyable, reducing monotony, and increasing students' emotional connection with educational tasks. In traditional instructional settings, students may experience academic activities as repetitive or externally imposed; however, game-based activities can increase perceived challenge, autonomy, and interest. This mechanism may explain why the experimental group showed a considerable increase in academic engagement compared with the control group. The finding is also compatible with the work of McFerren, who showed that motivation and engagement are associated with academic achievement among students (22). Although the present study did not directly assess academic achievement, the enhancement of engagement may be considered an important prerequisite for improved learning outcomes.

Another important finding of the present study was the significant effect of educational computer games on academic self-efficacy. Academic self-efficacy reflects students' beliefs about their ability to successfully perform academic tasks and overcome learning challenges. Educational computer games may increase academic self-efficacy by providing repeated opportunities for mastery experience, immediate feedback, gradual progression, and visible indicators of success. When students can try again after failure, correct their mistakes, and observe their own progress, they are more likely to develop confidence in their academic abilities. This interpretation is supported by Cheng, who emphasized the importance of academic self-efficacy in relation to assessment and students' interpretation of their educational performance (20). In game-based learning, assessment is often embedded in the learning process itself, allowing students to receive continuous feedback rather than relying only on formal evaluation. Such feedback can reduce uncertainty and strengthen students' beliefs that academic success is achievable through effort and strategy.

The improvement in academic self-efficacy is also consistent with studies that have identified self-efficacy as a core predictor of adaptive academic functioning. Amani and Alimoradi presented a model in which academic self-efficacy was related to academic engagement and academic procrastination through the mediating role of academic burnout (1). This suggests that students who feel more capable academically are more likely to remain engaged and less likely to withdraw from learning tasks. Similarly, Raji showed that academic self-efficacy predicts academic buoyancy among secondary school students (4). Rezaei Oshiani et al. also demonstrated that academic self-efficacy mediates the relationship between critical thinking and academic buoyancy among gifted students (5). These findings support the present result by showing that self-efficacy is closely connected with resilience, persistence, and adaptive academic behavior. Educational computer games may enhance these outcomes by allowing students to experience challenge in a controlled, motivating, and mastery-oriented environment.

The present findings can also be explained through the relationship between self-efficacy, self-regulation, and academic resilience. Tamannaeifar and Arbabi Qahroudi found that self-regulation and self-efficacy are related to academic buoyancy through the mediating role of academic resilience (7). Veys Karami et al. also showed that basic psychological needs mediate the relationship between academic self-efficacy and academic buoyancy (8). Zahed Babolan and Karimianpour reported that academic self-efficacy plays a mediating role in the relationship between academic optimism and academic buoyancy (6). These studies collectively indicate that academic self-efficacy is part of a broader motivational and adaptive system. In the present study, educational computer games may have supported this system by increasing students' sense of competence, autonomy, and progress. When students interact with educational games, they are often required to regulate attention, select

strategies, monitor outcomes, and persist after errors. These processes can strengthen both engagement and self-efficacy because students are actively involved in learning and can attribute progress to their own effort and performance.

The results also correspond with research on digital and computer-based educational games. Es-Sajjade and Paas emphasized that educational theories should inform computer game design and that game-based environments can be effective when they are aligned with learning principles and cognitive requirements (11). This point is important because not every digital game has educational value. The effectiveness of educational computer games depends on the degree to which game mechanics are connected to instructional objectives, feedback, scaffolding, and meaningful practice. The present study supports this view by showing that when educational games are used as part of an instructional intervention, they can significantly improve psychological learning outcomes. Similarly, Martinez et al. reviewed evidence on entertainment video games for academic learning and concluded that games may contribute to learning when they are appropriately selected and instructionally relevant (13). Tepho and Srisawasdi also reported that tablet-based digital games can influence mathematics learning performance (12). Although the present study focused on academic engagement and academic self-efficacy rather than mathematics performance, the findings are consistent with the broader conclusion that digital games can support learning-related outcomes when used purposefully.

The distinction between educational computer games and uncontrolled recreational gaming is essential for interpreting the findings. Some previous studies have shown that excessive or addictive use of online games and the internet may negatively affect academic functioning. Sun et al. found that online game addiction was associated with reduced academic achievement motivation through the mediating role of learning engagement (14). Zhang et al. also reported that adolescents' academic engagement mediates the relationship between internet addiction and academic achievement (15). In addition, Shirvani Safdarabadi examined social factors affecting adolescents' use of computer games and their relationship with psychosocial health (16). These studies do not contradict the present findings; rather, they clarify that the educational effect of games depends on their purpose, structure, content, and supervision. While excessive gaming may reduce motivation and engagement, educational computer games can have positive effects when they are embedded in a structured learning process and directed toward academic objectives.

The findings are also consistent with research conducted in virtual and technology-mediated learning contexts. Yahyaabadi showed that students' academic engagement during COVID-19 conditions could be predicted by teachers' quantum skills in the teaching-learning process (18). Amiransari examined diagnostic, formative, and final assessment in the SHAD virtual space and highlighted the importance of assessment processes in learning and academic engagement (19). Educational computer games may combine several of these effective elements by providing interaction, feedback, formative assessment, and motivational stimulation. In this sense, educational games can be viewed not merely as technological tools, but as managed instructional environments that organize learning tasks, feedback, and student participation. This interpretation is also related to the concept of dynamic competencies and meta-learning in management literature, where adaptation, learning from experience, and strategic adjustment are considered important for performance improvement (17). In educational settings, students similarly need opportunities to adapt their strategies, learn from errors, and improve performance through repeated practice.

The present study further supports prior local research on the effectiveness of educational computer games in academic contexts. Rajabpour Savari showed that entertaining and systematic educational computer games can influence elementary students' mathematics achievement (10). The present study extends this line of evidence by showing that educational computer games are not only related to achievement-oriented outcomes, but also to motivational and self-belief outcomes among secondary school students. This extension is important because academic engagement and academic self-efficacy are

foundational variables that may influence long-term learning, persistence, and academic adjustment. Furthermore, the findings are consistent with Gerbino et al., who highlighted the importance and measurability of multidimensional perceived self-efficacy among adolescents across cultural contexts (21). Since the participants in the present study were secondary school students, the improvement in academic self-efficacy is especially meaningful because adolescence is a critical period for the formation of academic confidence and learning identity.

Overall, the findings indicate that educational computer games can be an effective instructional intervention for enhancing academic engagement and academic self-efficacy. The results suggest that students benefit from learning environments that are interactive, feedback-rich, motivating, and structured around active participation. Educational computer games appear to strengthen students' involvement in academic tasks by increasing interest, persistence, and cognitive activity. At the same time, they may enhance academic self-efficacy by providing mastery experiences, immediate feedback, and opportunities to experience success. Therefore, from both educational and managerial perspectives, game-based learning can be considered a promising approach for improving the quality of teaching-learning processes, particularly when it is implemented with clear instructional goals and appropriate supervision.

The present study had several limitations that should be considered when interpreting the findings. First, the sample size was limited to 30 students, which may restrict the generalizability of the results to wider student populations. Second, the study used convenience sampling, and although participants were randomly assigned to the experimental and control groups, the initial selection of participants was not fully random. Third, the study was conducted with students in the second cycle of secondary education, so the findings may not be directly applicable to students in other educational levels. Fourth, the study assessed outcomes only at the pretest and posttest stages and did not include a follow-up phase to determine the stability of the intervention effects over time. Finally, the study relied on self-report questionnaires, which may be influenced by response bias, social desirability, or students' temporary emotional states.

Future studies are recommended to replicate this research with larger and more diverse samples across different educational levels, schools, and geographic regions. Researchers should also use randomized controlled designs where possible to increase the internal validity of the findings. Future research could include a follow-up assessment to examine whether the effects of educational computer games on academic engagement and academic self-efficacy remain stable over time. It is also suggested that future studies compare different types of educational games, such as individual versus collaborative games, competitive versus noncompetitive games, and subject-specific versus general cognitive games. In addition, future research could examine mediating variables such as motivation, academic emotions, self-regulation, perceived competence, and learning strategies to clarify the mechanisms through which educational computer games influence academic outcomes.

Educational administrators, school counselors, curriculum planners, and teachers are encouraged to consider the purposeful use of educational computer games as a complementary instructional strategy. These games should be selected based on students' age, learning needs, curriculum objectives, and cognitive level. Teachers should integrate educational games into structured lesson plans rather than using them as unrelated recreational activities. It is also important to monitor students' use of digital games to ensure that game-based learning remains focused, balanced, and academically meaningful. Schools can provide teacher training programs on the design, selection, and implementation of educational games so that teachers can use them effectively to increase students' engagement, confidence, and active participation in learning.

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AI Use Statement

Artificial intelligence tools were used only for language support and editorial refinement. The conceptual design, literature selection, argument development, and final scholarly responsibility remain entirely with the authors.

Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adhered in conducting and writing this article.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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