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Original Article

Effectiveness of Gamified Scratch-Based Learning Environment on Self-Efficacy, Perceived Usefulness, and Response Efficacy Among Students

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ABSTRACT

Background: With the rise of new technologies, education has increasingly integrated technology into teaching and learning processes, which enhances the appeal and effectiveness of educational content while fostering students' skills for future challenges. This study aimed to examine the effectiveness of a gamified smart course on students' self-efficacy, perceived usefulness, and response efficacy regarding technology integration in teaching.

Methods: This research used a quasi-experimental design with pre-test and post-test measures, including a control group. The participants were all seventh-grade female students from schools in Ahvaz, Iran, during September 2023 to May 2024. A total of 40 students were selected and divided into two groups of 20. They were randomly assigned to either the experimental group (which used a gamified smart learning approach) or the control group (which followed traditional teaching methods). Data were gathered using standard questionnaires assessing online learning self-efficacy, perceived usefulness, and response efficacy. The experimental group received instruction through game-based e-learning software, while the control group was taught using conventional methods. Data analysis was conducted using univariate Analysis of Covariance (ANCOVA) with SPSS version 26.

Results: At baseline, independent t-tests revealed no significant differences between the experimental and control groups in self-efficacy (experimental: 73.20±2.33; control: 71.40±1.82, P=0.56), perceived usefulness (experimental: 12.35±0.40; control: 11.85±0.37, P=0.12), and response efficacy (experimental: 9.90±0.55; control: 9.35±0.58, P=0.14). Following the intervention, ANCOVA analyses controlling for pre-test scores demonstrated significant group differences across all three outcomes. The experimental group showed higher post-test self-efficacy (89.55±2.99) compared to the control group (69.30±1.58), P<0.001. Perceived usefulness was greater in the experimental group (13.35±0.32) than in the control group (11.35±1.47), P=0.001. Response efficacy was significantly higher in the experimental group (13.20±0.89) compared to the control group (9.45±0.40), P<0.001. These findings confirm the positive impact of the intervention on all three outcomes.

Conclusion: The findings highlight the potential of gamified smart courses as a valuable educational tool. Future studies could investigate their long-term effects and applicability in diverse educational settings.

Keywords: Educational Technology, Self Efficacy, Perception, Teaching, Students, Computer-Assisted Instruction, Video Games

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Introduction

The integration of technology into educational practices has become one of the main strategies for improving educational quality in contemporary educational systems (1). With the rapid expansion of digital technologies and their increasing presence in educational environments, the success of technology-enhanced learning is no longer limited to the mere availability of technological tools; rather, it depends largely on learners' psychological readiness to engage effectively with these technologies (2). Accordingly, examining psychological constructs related to the acceptance and effective use of technology is considered a fundamental prerequisite for designing effective technology-enhanced learning environments (1, 2).

Among these constructs, self-efficacy is recognized as one of the most fundamental psychological factors in technology-enhanced learning. Rooted in Bandura's Social Cognitive Theory (SCT), self-efficacy refers to learners' beliefs in their ability to successfully perform tasks within digital learning environments (3). Research indicates that students with higher levels of self-efficacy demonstrate more active engagement in technology-based activities (4, 5), show greater persistence when facing challenges (6), and achieve better learning performance (7). Therefore, self-efficacy not only initiates learners' interaction with technology but also serves as a foundation for the development of subsequent positive attitudes toward technology-enhanced learning (8).

Building on this perspective, self-efficacy facilitates the formation of perceived usefulness, which is a key component of the Technology Acceptance Model (9). Perceived usefulness refers to the belief that using technology can enhance learning performance and is worth the effort invested (10). When students feel capable of using technology effectively, they are more likely to perceive it as a useful, efficient, and meaningful tool for learning (11). Thus, perceived usefulness can be viewed as a natural outcome of self-efficacy that shapes learners' attitudes toward the educational value of technology (12).

Within this cognitive process, response efficacy plays a complementary and reinforcing role. Derived from Protection Motivation Theory (13), response efficacy refers to learners' beliefs that their efforts and actions in response to challenges will lead to successful outcomes (14). In technology-enhanced learning environments, when students observe that their efforts genuinely result in progress, they become more inclined to persist in learning activities and actively confront difficulties (15). In this way, response efficacy creates a vital link between beliefs in personal capability and the continuation of adaptive learning behaviors (16).

In this context, gamification as an instructional approach has the potential to simultaneously strengthen all three of these constructs. Gamified course elements such as immediate feedback, progressive challenges, progress indicators, and rewards provide repeated mastery experiences that enhance students' self-efficacy (17). These successful experiences also help learners better recognize the practical value of technology, thereby increasing perceived usefulness (18). Moreover, witnessing the beneficial results of effort within gamified learning contexts strengthens response efficacy and fosters an ongoing cycle of motivation and engagement in technology-supported learning environments (19).

Despite increasing evidence highlighting the positive impact of gamification in educational settings, there is still a lack of studies that concurrently investigate self-efficacy, perceived usefulness, and response efficacy, particularly in early secondary education and in non-Western cultural environments (20). This gap is especially notable in Iran, where the education system is rapidly transitioning toward extensive integration of digital technologies (2). Accordingly, the present study focused on technology-enhanced learning environments and aimed to examine the effectiveness of a gamified course on self-efficacy, perceived usefulness, and response efficacy among female seventh-grade students.

Methods

Study Design and Setting

This research employed a quasi-experimental design with a pre-test and post-test structure and was conducted in schools in Ahvaz, Iran, between September and December 2023. Participants were randomly allocated to either the experimental or control group. Before the intervention, both groups completed questionnaires measuring self-efficacy, perceived usefulness, and response efficacy as baseline (pre-test) assessments. Statistical analyses were planned to determine the comparability of the groups at baseline. Subsequently, the experimental group participated in a game-based learning program, whereas the control group received conventional instruction. After the intervention, the same set of questionnaires was administered as a post-test, and the collected data were analyzed using appropriate statistical techniques.

Participants and Sampling

The study population comprised female middle school students in Ahvaz, Iran, from September 2023 to May 2024. In collaboration with the Ahvaz Department of Education, schools equipped with sufficient technological resources (such as computers or tablets) to support the game-based learning intervention were identified. Due to practical limitations and the requirement for such infrastructure, a convenience sampling method was adopted. From the eligible schools, 40 students who met the inclusion criteria and volunteered to participate were recruited. While this strategy facilitated the feasibility of the study, the potential lack of representativeness of the broader student population in Ahvaz limits the generalizability of the findings. Based on these conditions, the study is categorized as a quasi-experimental design with random assignment.

A list of eligible participants was prepared based on predefined inclusion criteria, including written parental consent, enrollment in the seventh grade, regular attendance (no more than two absences in the preceding month), and absence of significant physical or psychological conditions that could interfere with learning. Exclusion criteria comprised having more than two absences, more than three instances of tardiness exceeding 15 minutes, lack of participation in study activities, or withdrawal from the study.

Using randomization software (Excel), the 40 participants were randomly allocated into two equal groups (experimental and control), ensuring equal probability of assignment. The experimental group participated in the game-based learning intervention across eight sessions, each lasting 40 minutes, whereas the control group received conventional instruction. To ensure consistency in content delivery and instructional approach, all sessions were conducted by the same teacher.

The sample size was determined based on the mean and standard deviation reported in a previous quasi-experimental study by Moazami and colleagues (21), which compared virtual and traditional educational methods among Iranian dental students and reported an effect size of 0.66. Using the standard formula for comparing two independent means, with a significance level of $\alpha=0.05$ and statistical power of 0.80, the minimum required sample size was estimated to be 18 participants per group. To improve accuracy and account for potential attrition, the final sample size was increased to 20 participants in each group.

Intervention/Procedures

In this study, the experimental group (20 students) received an intelligent, gamified instructional program focused on game development using Scratch version 3 (Scratch 3.x). The intervention was delivered through the online Scratch platform (https://scratch.mit.edu/), accessed via Google Chrome on Windows 10 systems, and comprised eight sessions of 40 minutes each. This technology-enhanced program promoted interactive learning by combining Scratch's visual programming environment with gamification strategies. Its main instructional components included: 1) an interactive Scratch environment for designing educational games, 2) immediate feedback for code correction, 3) a staged structure with gradually increasing complexity, and 4) personalization of activities based on student ability.

Gamification elements included: 1) a scoring system for project completion (e.g., animations or game creation), 2) sessionlevel progression (from basic concepts to more complex games), 3) virtual badges for creativity and collaboration, 4) a group leaderboard to encourage healthy competition, and 5) narrative challenges (such as designing educational games for mathematics).

In contrast, the control group (20 students) received the same instructional content through traditional lecturebased teaching and written exercises, without any technology or gamification components. Post-test questionnaire data were collected to evaluate the impact of the gamified intelligent intervention compared with the traditional approach on students' self-efficacy, perceived usefulness, and response efficacy.

Tools/Instruments

Three standardized, validated questionnaires were employed to measure students' online learning self-efficacy, perceived usefulness, and response efficacy.

Student Self-Efficacy Questionnaire: The Student Self-Efficacy Questionnaire was adapted into Persian based on Yavuzalp and Bahcivan (2020), whose study confirmed the instrument's validity and reliability (22).

Validity and Reliability - In the present study, the Persian version underwent content validity assessment by 10 experts in educational technology and psychometrics. The Content Validity Index (CVI) for individual items ranged from 0.80 to 1.00, with an overall average CVI of 0.92. The Content Validity Ratio (CVR) for the items ranged from 0.62 to 1.00, which, according to Lawshe's table and the number of experts, indicates adequate content validity (23). The Cronbach's alpha coefficients demonstrated acceptable internal consistency across stages: pre-test (control: 0.78; experimental: 0.86) and post-test (control: 0.73; experimental: 0.90).

Student Perceived Usefulness Questionnaire: This questionnaire was developed based on the study by Ateş and Kölemen (2025), with its original validity and reliability previously established (24).

Validity and Reliability - In this study, 10 experts evaluated the Persian version, yielding item-level CVI values between 0.90 and 1.00 and an overall CVI of 0.95. The CVR values ranged from 0.80 to 1.00, indicating strong content validity (23). The Cronbach's alpha coefficients were as follows: pre-test (control: 0.71; experimental: 0.71) and post-test (control: 0.73; experimental: 0.72).

Student Response Efficacy Questionnaire: Similar to the Perceived Usefulness Questionnaire, this instrument was also developed based on Ateş and Kölemen (2025), with validity and reliability confirmed in the original study (24).

Validity and Reliability - In the present research, the Persian version's content validity was reviewed by 10 experts, with item-level CVI values ranging from 0.90 to 1.00 and an overall average of 0.95. CVR values varied from 0.80 to 1.00, reflecting high content validity (23). The Cronbach's alpha coefficients were acceptable: pre-test (control: 0.77; experimental: 0.72) and post-test (control: 0.79; experimental: 0.71).

Cronbach's alpha coefficients for all variables in both pre-test and post-test phases, across control and experimental groups, exceeded 0.70, indicating satisfactory internal consistency and supporting the reliability of the measurement tools.

Data Collection

Data were gathered using standard questionnaires assessing online learning self-efficacy, perceived usefulness, and response efficacy. The intervention was implemented using the Scratch online platform (https://scratch.mit.edu/), which participants accessed through Google Chrome on Windows 10 computers.

The control group received the instructional content through traditional lecturebased teaching and written exercises, without any technology or gamification components.

Data Analysis

Data were analyzed using SPSS version 26. Descriptive statistics, including mean, standard deviation, frequency, and percentage, were computed to summarize demographic characteristics and study variables. Independent samples t-tests were applied to assess baseline equivalence between the experimental and control groups based on pre-test scores. Before performing the Analysis of Covariance (ANCOVA), the assumptions of normality and homogeneity of variances were evaluated using the Shapiro–Wilk and Levene's tests, respectively. It should be noted that ANCOVA is relatively robust to moderate violations of the homogeneity of variances assumption (25). To examine the study hypotheses, ANCOVA was conducted while adjusting for pre-test scores as covariates. Statistical significance was determined at an alpha level of 0.05. Additionally, effect sizes (partial eta squared) were reported to indicate the magnitude of the observed effects.

Ethics - Participation in this study was entirely voluntary. Written informed consent was obtained from all participants, who completed the questionnaires after receiving comprehensive information about the study objectives. All ethical standards were rigorously upheld, including respect for participants' rights, compliance with authorship criteria, and adherence to appropriate research design principles. The study protocol was reviewed and approved by the Ethics Committee of Payame Noor University, Tehran, Iran.

Results

The study included 40 female seventh-grade students who were randomly assigned to either the experimental group (n=20) or the control group (n=20). All participants completed the study, and no attrition was observed during the intervention period. The flow of participants through the study is presented in Figure 1 according to the CONSORT 2010 flow diagram (26).

Baseline analyses were conducted to assess the comparability of the two groups prior to the intervention. Table 1 presents the demographic characteristics of the study participants and the results of baseline group comparisons. The average age of participants was approximately 12.65 years, and the mean Grade Point Average (GPA) was 17.8. Results from independent t-tests assessing differences in mean age and GPA, together with a chi-square test examining SES distribution, indicated no statistically significant differences between the groups. These results suggest that the experimental and control groups were demographically comparable at baseline.

Independent t-tests indicated no significant differences between the experimental and control groups in pre-test measures of self-efficacy, perceived usefulness, and response efficacy ($P>0.05$), confirming baseline homogeneity. Although independent t-tests confirmed baseline homogeneity between the experimental and control groups, ANCOVA was employed. The rationale for using ANCOVA extends beyond correcting initial group differences. By incorporating pre-test scores as covariates, ANCOVA minimizes error variance, enhances statistical power, and yields more accurate estimates of the intervention effect. This method also accounts for small, non-significant baseline variations, thereby improving the overall validity and reliability of the findings.

Following the confirmation of baseline equivalence, the assumptions underlying the covariance model were examined. As shown in Table 2, the Shapiro–Wilk test confirmed that all study variables followed a normal distribution ($P>0.05$).

The analysis of homogeneity of regression slopes indicated that the interaction between group and pre-test scores was not statistically significant for self-efficacy ($F(1, 36)=0.73$, $P=0.39$), perceived usefulness ($F(1, 36)=0.67$, $P=0.41$), and response efficacy ($F(1, 36)=3.74$,

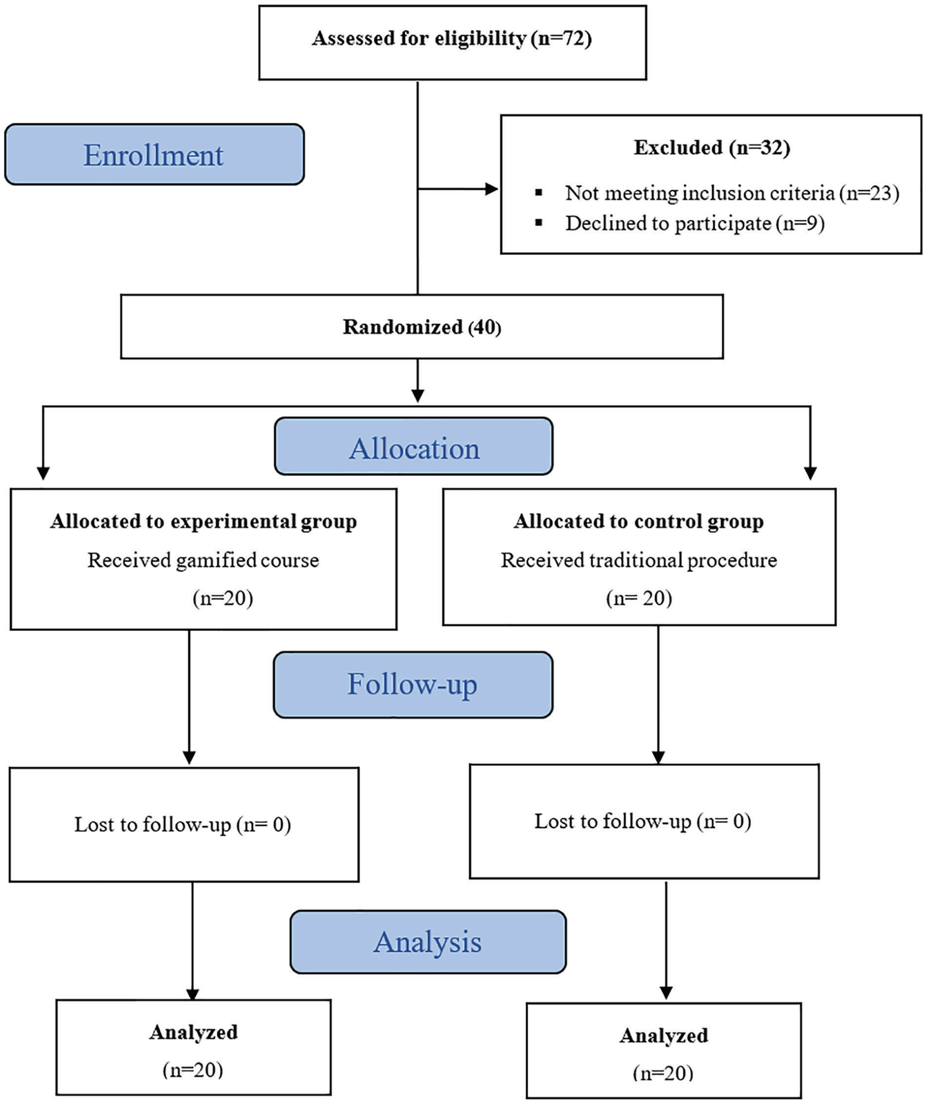

Figure 1: The participants' recruitment flow diagram

P=0.05). These results confirm that the assumption of homogeneity of regression slopes was met.

Levene's test indicated violations of the homogeneity of variances assumption for self-efficacy (F=4.74, P=0.01), perceived usefulness (F=4.57, P=0.03), and response efficacy (F=8.12, P=0.006). Although Levene's test revealed violations of homogeneity of variances, ANCOVA is considered robust to moderate violations, when the group sample sizes are equal.

Table 3 presents the raw descriptive statistics (Mean±SD) for selfefficacy,

Table 1: Baseline demographic characteristics and group comparisons

Variable	Experimental Group (n=20)	Control Group (n=20)	Total Sample (n=40)	Test Statistic	P-value
Age (years)	12.60±0.50	12.70±0.40	12.65±0.45	t=0.50	0.62
GPA	17.70±1.30	17.90±1.10	17.80±1.20	t=0.62	0.54
Low-income	6 (30%)	5 (25%)	11 (27.5%)	χ^2=0.42	0.81
Middle-income	11 (55%)	12 (60%)	23 (57.5%)		
High-income	3 (15%)	3 (15%)	6 (15%)		

* Mean±SD is reported for quantitative variables and N (%) is reported for qualitative variable; GPA: Grade Point Average.

Table 2: Results of data distribution of research variables

Groups	Variables	P-value
Control	Self-efficacy pre-test	0.25
	Self-efficacy post-test	0.39
Experimental	Self-efficacy pre-test	0.12
	Self-efficacy post-test	0.08
Control	Perceived usefulness pre-test	0.25
	Perceived usefulness post-test	0.67
Experimental	Perceived usefulness pre-test	0.14
	Perceived usefulness post-test	0.18
Control	Response efficacy pre-test	0.08
	Response efficacy post-test	0.10
Experimental	Response efficacy pre-test	0.41
	Response efficacy post-test	0.66

Table 3: Descriptive statistics of study variables at pre-test and post-test by group

Groups	Variables	N	Mean±SD
Control	Self-efficacy pre-test	20	71.40±1.82
	Self-efficacy post-test	20	69.30±1.58
Experimental	Self-efficacy pre-test	20	73.20±2.33
	Self-efficacy post-test	20	89.55±2.99
Control	Perceived usefulness pre-test	20	11.85±0.37
	Perceived usefulness post-test	20	11.35±1.47
Experimental	Perceived usefulness pre-test	20	12.35±0.40
	Perceived usefulness post-test	20	13.35±0.32
Control	Response efficacy pre-test	20	09.35±0.58
	Response efficacy post-test	20	09.45±0.40
Experimental	Response efficacy pre-test	20	09.90±0.55
	Response efficacy post-test	20	13.20±0.89

perceived usefulness, and response efficacy at both pretest and posttest across the experimental and control groups. Differences observed at posttest suggest potential intervention effects, which were further examined using ANCOVA to statistically control for pretest scores and provide adjusted comparisons.

The ANCOVA analyses revealed significant group differences across all three dependent variables after controlling for pre-test scores. For self-efficacy, the experimental group demonstrated higher adjusted post-test scores (M=89.55) compared to the control group (M=69.30), $F(1, 37)=67.68$, $P<0.001$, partial $\eta^2=0.64$, indicating a large effect size. This suggests that approximately 65% of the variance in self-efficacy scores was explained by group membership, representing a substantial and practically meaningful effect.

Similarly, perceived usefulness was higher in the experimental group (M=13.35) than in the control group (M=11.35), $F(1, 37)=12.37$, $P=0.001$, partial $\eta^2=0.25$, reflecting a medium effect size. In practical terms, about 25% of the variance in perceived usefulness was accounted for by the intervention, indicating a meaningful effect.

Finally, response efficacy was significantly higher in the experimental group (M=13.20) compared to the control group (M=9.45), $F(1, 37)=19.79$, $P<0.001$, partial $\eta^2=0.34$, suggesting a moderate to large effect. This corresponds to approximately 34–35% of the variance explained, again representing a substantial and practically meaningful effect. Overall, these findings confirm the positive impact of the intervention on all three outcomes (Table 4).

Table 4: Summary of ANCOVA results for study outcomes

Dependent Variable	Source	Type III Sum of Squares	df	Mean Square	F	P-value	partial η^2
Selfefficacy	Intercept	183.381	1	183.381	3.584	0.066	-
	Pre-test Selfefficacy	2480.107	1	2480.107	48.475	<0.001	-
	Group	3462.464	1	3462.464	67.675	<0.001	0.647
	Error	1893.03	37	51.163	-	-	-
	Total	260807.402	40			-	-
Perceived usefulness	Intercept	150.445	1	150.445	44.518	<0.001	-
	Pre-test Perceived usefulness	2.06	1	2.06	0.61	0.440	-
	Group	41.813	1	41.813	12.373	0.001	0.251
	Error	125.04	37	3.379	-	-	-
	Total	6268	40	-	-	-	-
Response efficacy	Intercept	30.543	1	30.543	5.61	0.023	-
	Pre-test Response efficacy	164.707	1	164.707	30.253	-	-
	Group	107.726	1	107.726	19.787	-	0.348
	Error	201.443	37	5.444	-	-	-
	Total	-	-	-	-	-	-

Discussion

The primary objective of this study was to examine the effectiveness of an eight-session gamified intelligent instructional program in enhancing three key psychological constructs—self-efficacy, perceived usefulness, and response efficacy—among seventh-grade female students. By focusing on these variables, the study sought to explore how gamified, technology-enhanced learning environments can support students' psychological readiness for engaging with digital tools. The findings provided empirical evidence that such interventions can positively influence students' beliefs about their capabilities, their perceptions of technology's value, and their confidence in successfully overcoming learning challenges. These outcomes are particularly relevant in contexts where students have limited prior exposure to educational technologies, highlighting the importance of structured and supportive digital learning experiences.

The results of this quasi-experimental study demonstrated that the gamified course significantly improved all three targeted constructs. These findings are consistent with established theoretical frameworks, including SCT, the Technology Acceptance Model (TAM), and Protection Motivation Theory (PMT), all of which emphasize the importance of cognitive and motivational factors in shaping individuals' engagement with technology. The observed improvements suggest that gamification does not merely increase surface-level engagement but also contributes to deeper psychological processes that facilitate meaningful learning and technology adoption.

A notable outcome of the study was the significant enhancement of students' self-efficacy, which aligns with prior research (8, 27-31). This improvement can be interpreted through the lens of SCT, which posits that individuals develop stronger beliefs in their abilities through mastery experiences, social modeling, and feedback. In the context of this study, the gamified environment provided students with incremental challenges that were carefully structured to match their skill levels. As students successfully completed tasks, they experienced a sense of accomplishment that reinforced their confidence. Additionally, features such as leaderboards and peer observation allowed students to learn vicariously, further strengthening their self-beliefs (5, 11, 32-34).

However, it is important to note that the magnitude of this effect was smaller than that reported in studies utilizing more immersive technologies, such as virtual reality, or interventions with longer durations (29). This discrepancy may be attributed to several factors. First, technological infrastructure limitations may have constrained the richness of the learning experience, thereby reducing its overall impact. Second, the relatively short duration of the intervention limited opportunities for repeated practice and reinforcement, which are critical for the development of strong and enduring self-efficacy beliefs. These findings suggest that while gamification is effective, its impact may be amplified when combined with more advanced technologies and extended implementation periods.

In terms of perceived usefulness, the study found a statistically significant but relatively small effect. This result is consistent with previous research grounded in the TAM (20, 27, 29, 35), which indicates that interactive features and immediate feedback can positively influence users' perceptions of technology. In this study, students were exposed to a learning environment where digital tools were integrated into meaningful tasks, allowing them to experience the functional benefits of technology firsthand. However, the modest effect size suggests that changes in perceived usefulness may require a longer period to develop.

One possible explanation is that perceived usefulness is a more cognitively complex construct compared to self-efficacy. While self-efficacy can be influenced relatively quickly through direct experience and feedback, perceptions of usefulness often depend on accumulated experiences and a deeper understanding of how technology contributes to learning outcomes. In the context of the Iranian educational system, where students may have limited prior exposure to digital learning environments, the formation of such perceptions may be further delayed. Therefore, longer-term interventions that provide sustained exposure to technology are likely necessary to produce more substantial changes in perceived usefulness.

The study also revealed a significant increase in response efficacy, which is consistent with findings from research based on Protection Motivation Theory (19, 27, 30, 35-38). Response efficacy refers to the belief that a given behavior will effectively lead to desired outcomes. In this case, students developed stronger confidence that their efforts in using technology would result in successful learning outcomes. This improvement can be attributed to the continuous feedback mechanisms embedded within the gamified course. By providing immediate and visible indicators of progress, the system reinforced the connection between effort and success, encouraging students to persist in the face of challenges.

Despite this positive outcome, the effect size for response efficacy was smaller compared to studies involving older students or longer interventions (37). This finding suggests that factors such as cognitive maturity and exposure duration play a critical role in shaping response efficacy beliefs. Younger students may require more time and experience to fully internalize the relationship between effort and outcome, particularly in technology-based learning contexts. Consequently, future interventions should consider extending the duration of exposure and incorporating age-appropriate strategies to strengthen these beliefs more effectively.

From a practical standpoint, the study offers several important implications for educators and instructional designers. First, the significant improvement in self-efficacy suggests that gamified learning environments can serve as effective entry points for introducing technology in education. For students with limited prior experience, these environments provide a supportive and engaging way to build confidence and reduce anxiety associated with digital tools. Short, structured gamified modules can therefore play a crucial role in facilitating the transition to more advanced forms of technology-enhanced learning. This finding is supported by prior research indicating that self-efficacy plays a foundational role in students' willingness to adopt and persist in using new technologies (18, 39).

Second, the findings related to perceived usefulness emphasize the importance of aligning gamification with clear educational objectives. Simply incorporating game elements is not sufficient; these elements must be meaningfully integrated into the learning process in ways that clearly demonstrate the practical value of technology. When students can see how digital tools enhance their understanding and problem-solving abilities, they are more likely to develop positive attitudes toward their use. This aligns with previous studies highlighting that perceived usefulness is a key determinant of technology acceptance and sustained engagement in digital learning environments (18, 40). This highlights the need for thoughtful pedagogical design rather than reliance on technology for its own sake.

Third, the enhancement of response efficacy has important implications for sustaining student engagement. By designing gamified systems that clearly link effort to progress, educators can encourage persistence and resilience among learners. This is particularly important for early adolescents, who may be more prone to disengagement when faced with challenging tasks. Transparent progress indicators, achievable goals, and continuous feedback can help maintain motivation and support adaptive learning behaviors. Prior research in motivational psychology and educational technology supports the role of feedback and perceived control in strengthening persistence and learning outcomes (33, 41).

Overall, these findings suggest that gamified instruction, when thoughtfully designed, can function as a psychologically informed strategy for supporting students' engagement with technology-enhanced learning. Rather than acting solely as a motivational layer, gamification contributes to a structured psychological progression that strengthens learners' beliefs, attitudes, and behaviors toward technology use. This perspective is consistent with broader frameworks in educational psychology that emphasize the interaction between cognitive, motivational, and environmental factors in shaping learning experiences (39, 41).

In conclusion, this study demonstrates that gamified instruction, when carefully designed and implemented, can function as a powerful, psychologically informed strategy for promoting engagement with technology-enhanced learning. Rather than serving merely as a motivational tool, gamification can facilitate a deeper transformation in students' beliefs and attitudes toward learning with technology. Future research should explore the long-term effects of such interventions and investigate how different design elements can be optimized to maximize their impact across diverse educational contexts, as also recommended in recent systematic reviews on digital and gamified learning (33, 40).

Limitations and Suggestions

This study has several limitations. A key limitation is the relatively small sample size, which may limit the generalizability of the findings; a larger sample could improve result validity. Moreover, the restricted geographic scope suggests that the findings are primarily applicable to local settings, and wider investigations are necessary before extending conclusions to a national level. The brief duration of the intervention (eight sessions of 40 minutes each) further restricts the ability to assess long-term outcomes of the gamified smart course, highlighting the need for extended follow-up studies. In addition, the study focused solely on comparing gamified and traditional instructional methods, without incorporating alternative approaches such as blended or collaborative learning, thereby limiting the scope of comparison.

In terms of practical implications, teachers are encouraged to incorporate gamified tools into technology-related enrichment courses to strengthen students' practical skills and self-confidence. Developing interactive online platforms can further support the practice and enhancement of technological competencies and self-efficacy. It is also recommended that gamified courses emphasize real-world problem-solving to help students better appreciate the relevance of technology. Additionally, integrating interactive, game-based storytelling can make learning more engaging and aligned with students' needs. Designing gamified environments that provide immediate and tangible feedback may also promote positive emotional and cognitive outcomes.

Conclusion

This study underscores the potential of gamified intelligent courses as an approach to integrating technology into educational settings, particularly in contexts such as Iran. The incorporation of game-based elements was associated with improvements in self-efficacy, perceived usefulness, and response efficacy among seventh-grade female students, suggesting a promising strategy for enhancing technological literacy and learner engagement. Gamification may facilitate the alignment of motivational factors with effective technology use in learning environments.

Despite these contributions, the results should be interpreted with caution due to the relatively small sample size and limited geographic scope. While the findings may offer insights for local educational practice, further large-scale and diverse studies are necessary before broader generalizations or national policy recommendations can be made. Additionally, given the modest effect size observed for perceived usefulness, policymakers and educators may consider developing sustained, context-sensitive interventions to strengthen students' acceptance and effective use of technology.

Overall, gamified intelligent courses may represent a valuable instructional approach for fostering active learning and supporting students' readiness to engage with digital environments, although further evidence is required to confirm their broader educational impact.

Abbreviations

CVI: Content Validity Index
CVR: Content Validity Ratio
PMT: Protection Motivation Theory
SCT: Social Cognitive Theory
TAM: Technology Acceptance Model

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Authors' Contribution

SA designed and conceptualized the study and was responsible for collecting and analyzing the data. SA also prepared the initial manuscript draft, while TH oversaw the methodological approach and data analysis. Both authors contributed important revisions and approved the final manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

Ethical Considerations

All participants provided written informed consent and completed the questionnaires voluntarily. The study objectives were clearly explained to them. Additionally, all ethical principles, including respect for authorship rights and adherence to the study protocol, were fully observed. This study was approved by the Department of Educational Sciences at Payame Noor University, Tehran, Iran, under the ethical code IR.PNU.REC.1403.596.

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Availability of Data and Materials

Data can be accessed through published articles and their respective DOIs. Upon reasonable inquiry, the corresponding author can provide additional data, including the Persian version of the questionnaires.

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