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GAME-BASED LEARNING THROUGH PROGRAMMING: IMPACT ON PRESERVICE TEACHERS' LEARNING MOTIVATION

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ABSTRACT

Aim/Purpose	This research investigated how integrating programming into game-based learning influences preservice teachers' motivation. It specifically examined motivational changes through the Attention, Relevance, Confidence, and Satisfaction (ARCS) model. The study aimed to guide more effective implementations of game-based learning by highlighting instructional design strategies.
Background	Game-based learning has been increasingly recognized for its potential to engage learners through interactive and immersive experiences. This research builds on Dewey's Four Impulses and game-based learning frameworks to deepen understanding of motivational outcomes.
Methodology	An eight-week intervention was conducted with 11 preservice teachers enrolled in a Physical Computing course. The intervention featured the MakeCode Arcade programming platform and a structured four-stage model. Data were collected using Keller's Course Interest Survey before and after the intervention.
Contribution	This study provides insights into how the systematic integration of game-based learning and programming can enhance preservice teachers' motivation. It offers practical implications for preparing them to design and implement engaging game-based lessons in future classrooms.
Findings	The results showed significant increases in preservice teachers' attention and satisfaction after participating in game-based programming. While relevance and confidence did not show statistically significant gains, they still exhibited a positive trend. Overall, these findings suggest that immersing learners in game-

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	based learning within a programming curriculum effectively fosters engagement and key aspects of learning motivation.
Recommendations for Practitioners	Teachers could integrate game-based programming projects that actively engage learners through iterative design and peer collaboration. Providing frequent opportunities for feedback and redesign can sustain high levels of engagement. Additionally, incorporating tangible hardware tools can make the learning process more immersive and satisfying.
Recommendations for Researchers	Researchers should design interventions that connect programming tasks to learners' real-world teaching contexts, complement quantitative findings with qualitative insights, and explore motivational factors beyond the ARCS model. Employing larger sample sizes and fostering cross-institutional collaborations would further enhance the generalizability of future studies.
Impact on Society	Equipping future teachers with innovative instructional methods can enhance the overall quality of education, especially in increasingly digital and diverse learning environments. By fostering both motivation and competence, game-based learning approaches may lead to more engaging and equitable classrooms. In turn, society benefits from teachers who can creatively integrate technology into learning experiences.
Future Research	Given the small sample size in this study, future research should involve a larger group of participants to enhance generalizability. It would also be valuable to extend the intervention period to observe longer-term motivational changes, particularly in relevance and confidence. Comparative studies across different game-based platforms may further inform effective integration strategies in teacher education.
Keywords	game-based learning, programming education, motivation, preservice teachers, ARCS Model, MakeCode Arcade

INTRODUCTION

Papert (1998) presented his perspectives on children, games, and learning in the 1998 issue of Game Developer magazine. He argued that games provide a strong motivation for children to learn well and quickly, along with practice for improving learning skills. Therefore, games should be appropriately utilized as a learning strategy, and one of those strategies is for students to become game designers themselves. Kafai (1995) noted that when students engage as game designers, their involvement level increases in duration and intensity. In summary, learners are most engaged and effective when they assume the role of game designers in game-based learning.

Over the past decade, there has been a rapid increase in new toys, games, programming environments, and curricula that incorporate block-based programming features (Weintrop, 2019). Incorporating programming into the gameplay experience by leveraging learners' interest and enjoyment of games can provide a fully immersive programming experience within the game context (Weintrop & Wilensky, 2014). Students can take on the role of creative producers by designing their own animation, games, and content through programming (Resnick et al., 2009). Also, it is important to select appropriate games to engage students in learning and enhance the effectiveness of their learning (Voštinár, 2021). Roblox and Minecraft are among the most used games. Hernández et al. (2022) viewed Multiplayer Online Games such as Roblox as promoting immersion and long-term engagement in learning, with potential for developing social and language skills. Han et al. (2023) utilized

programming in STEM education. They stated that Roblox in learning has the advantage of enhancing cognitive and non-cognitive learning abilities and fostering positive attitudes among students. Zorn et al. (2013) demonstrated that the design of Minecraft's Code Blocks course is effective in improving non-programmers' perceptions and enhancing their ability to learn programming. Nebel et al. (2016) studied Minecraft from the perspective of its use in education and research. In addition, various attempts are being made to apply different games to education.

While much attention has been paid to students' motivation and engagement in game-based learning, the role of the teacher remains central. Hattie (2003) emphasized that the teacher is the most influential factor in shaping students' learning experiences and performances. In the context of game-based learning, teachers are not just facilitators but also take on the roles of co-developers or instructional designers (Molin, 2017). Watson et al. (2011) stressed the importance of identifying "teachable moments" during gameplay, an instructional skill that many teachers find challenging due to a lack of experience and knowledge. In fact, having experience with implementing games in teaching plays a key role in designing for such teachable moments. Teachers who have used games in class tend to perceive fewer barriers and express greater confidence in effectively integrating games into their practice (Watson & Yang, 2016).

This study examines how game-based learning can be integrated with programming instruction for preservice teachers and investigates the impact of this integration on their learning motivation. Preservice teachers are at a crucial stage in which exposure to innovative instructional methods can significantly shape their pedagogical beliefs and practices. Especially in today's classrooms, where student diversity is growing in terms of culture, learning styles, and cognitive characteristics (Cushner, 1992; Gerges, 2001), it has become increasingly important for future teachers to experience and adopt various instructional strategies. Thus, as an initial step toward equipping preservice teachers with the ability to design game-based instruction, this study investigates the effects of a programming-integrated game-based learning on their motivation as future educators.

LITERATURE REVIEW

GAME-BASED LEARNING

Salen and Zimmerman (2005) described a game as a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome. The key aspect of games is that they keep learners continuously engaged and interested in the learning process. One factor that helps sustain learners' interest in games is the interaction between game elements and the learners themselves, which positively influences their motivation and immersion in the learning process (Kapp, 2012). Kapp (2012) identified various game elements that drive engagement, but this study has selected and summarized the relevant game elements in Table 1.

Table 1. Game elements

Game element	Description
Abstraction of concepts and reality	A game based on complex subject matter works by reducing complexity and using broad generalizations to represent reality.
Goals	Game goals are specific and unambiguous.
Rules	Operational rules, fundamental rules, implicit rules, behavior rules, and educational rules.
Time	The most obvious is that time can be used as a motivator for player activity and action.
Reward structures	It was a powerful motivator to play the game again and again, and gave players a chance to socially interact in discussions.

Game element	Description
Feedback	Feedback in learning or playing games is designed to evoke the correct behavior, thoughts, or actions.
Level	Game level, playing a level, player level
Story	When a game has a story, it adds validity to the experience and meaning, providing context for the player as they complete tasks.

Game-based learning is defined as the combination of computer games and educational content (Prensky, 2003). It is considered effective in promoting immersion in the learning content, fostering active interaction, and offering two or more solutions within the overall context (Prensky, 2003). Game-based learning refers to an approach where games are utilized to achieve educational goals (Baik, 2006). It is a form of learning that leverages the intrinsic motivation provided by games to achieve extrinsic goals, such as educational objectives (Baik, 2006). In summary, game-based learning refers to the use of games within the learning process to help students reach educational objectives. It involves incorporating games directly into the learning experience, making the game itself part of the educational journey.

Bourgonjon et al. (2013) analyzed the beliefs underlying teachers' initial acceptance of game-based learning and highlighted the need for teacher education programs to demonstrate how games can enhance educational quality in specific contexts. Ucus (2015) found that while teachers recognized game-based learning as learning through media and cooperative learning, they faced challenges of implementation, such as limited instructional time, technical issues, and lack of collaborative opportunities. Gumbi et al. (2024) further confirmed that preservice teachers in South Africa hold favorable perceptions of it yet still encounter various barriers to its implementation (Bourgonjon et al., 2013; Kaimara et al., 2021; Ucus, 2015). To address these challenges, teacher preparation programs should provide time for teachers to build confidence with access to successful models and ongoing support (Ketelhut & Schifter, 2011).

For optimal effectiveness, instructional design should not only focus on creating games for educational purposes but also ensure their seamless integration with sound pedagogical strategies (Ke, 2008). Dewey (1900/2016), in his well-known *The School and Society*, emphasized the importance of engaging children in learning through their interests and curiosity, allowing them to construct their own knowledge. He classified the four key impulses in children's learning as Inquiry, Construction, Communication, and Expression. Park and Shin (2024) categorized programming lessons through game-based learning into four stages based on Dewey's four impulses (Table 2).

Table 2. Game-based learning stages in programming lessons

Stage	Learning activities
Inquiry	Present learning topics and activities Problem Identification
Construction	Create a game with programming Guide to a sample program
Communication	Share the game with others Share ideas for developing the game
Expression	Programming the developed game Expressing ideas in writing or drawing

There is research on MakeCode Arcade, one of the many intriguing learning environments for game-based learning. MakeCode Arcade is a web-based programming platform that provides an environment for users to create their own games using block coding. It also supports JavaScript and Python to facilitate a deeper understanding of the games they design. The first beta version was released in 2019, and the official version launched in 2020. The next beta version is currently under development. The MakeCode Arcade main page offers numerous tutorials, and the MakeCode Arcade editor consists of the simulator on the left, the Blocks Editor in the center, and the Blocks Palette on the right.

MakeCode Arcade offers the advantage of providing immediate feedback through its simulator, which functions like a game console, as well as through its debug mode. Another key benefit is its support for a variety of hardware connections. This allows students to test and run the 2D games they create, not only in a virtual environment but also on actual hardware devices. Also, users can choose from various types of game consoles and enjoy their games on real devices, enhancing the hands-on learning experience.

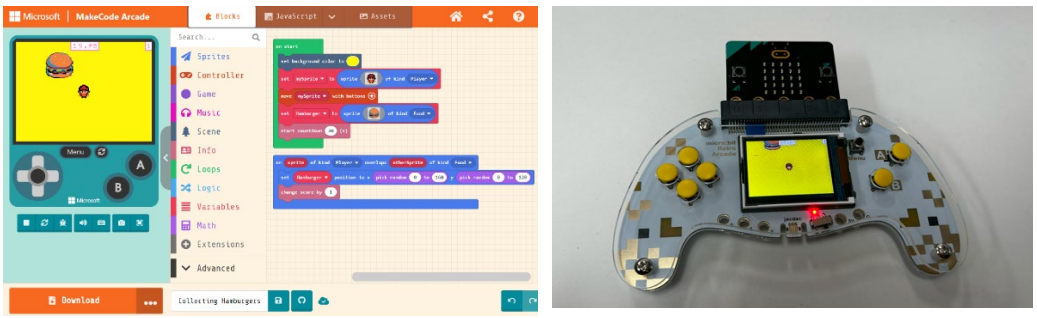

Figure 1. Makecode Arcade editor and a compatible game console

Mathrani et al. (2016) incorporated game-based learning into programming instruction. Their findings showed that students gained confidence in applying programming concepts through gameplay and were eager to support their cohorts throughout the learning process. Xu and Liu (2023) identified the advantages of MakeCode Arcade, stating that it is fully based on web program implementation functionality, allowing it to run on various old system environments and outdated hardware devices, demonstrating strong cross-platform compatibility. Voštinár (2021) researched the use of MakeCode Arcade as a new online learning environment that engages and sustains students' interest in elementary programming classes. This learning environment positively influenced students' learning motivation, and teachers recognized it as an effective learning setting that incorporates game principles, graphics, and animation elements.

Learning Motivation

Learning motivation is the driving force behind acquiring knowledge or skills that facilitate learning. Therefore, it focuses on participating in learning activities to achieve expected outcomes while experiencing enjoyment and satisfaction (Keller, 1987). Motivation is key to learning continuity and helps manage challenges and difficulties (Gopalan et al., 2017). Motivation frequently appears within the five key themes of competence, value, attributions, and interaction between individuals and the learning context (Cook & Artino, 2016). Games offer motivational benefits, encouraging them to learn materials required for successful gameplay (Oblinger, 2004). However, simply using games as learning tools solely because they are considered motivational is not appropriate. Game-based learning can integrate effective educational principles and has the potential to foster experiential, immersive, and engaging problem-based learning experiences (Whitton, 2007).

Keller (1984) proposed the ARCS Motivation Model through his research on how to use and design motivational strategies in learning. The original model is grounded expectancy-value theory, expanding the two components into four factors (Keller, 1979, 1987). The ARCS model, which stands for Attention, Relevance, Confidence, and Satisfaction, is designed to enhance learner motivation by addressing these four critical components in instructional design. Attention refers to capturing the learners' interest and stimulating their curiosity to learn. Relevance refers to making learning meaningful and connected to learners' goals, experiences, or future aspirations. Confidence refers to helping learners believe that they can succeed and take control of their own success. Finally, satisfaction involves reinforcing achievements through both internal and external rewards. As part of his research on developing motivational checklists based on the ARCS model, Keller (2010) presented a measurement tool called the Course Interest Survey (CIS) to investigate course interest. The CIS was designed to measure the extent to which learners are motivated and what they expect from a particular course. In this study, the CIS checklist was used to examine the impact of game-based learning activities on the learning motivation of preservice teachers.

METHOD

PARTICIPANTS

This study was conducted to investigate the impact of game-based learning through programming on learners' motivation. The study involved 11 preservice teachers enrolled in the Physical Computing course during the second semester at the university of education in Seoul, South Korea. The group consisted of two male and nine female students majoring in Elementary Computer Education.

PROCEDURES

In this study, 11 preservice teachers participated in an 8-week game-based learning program consisting of 16 sessions. Sessions 6 to 13 were designed according to the four stages of game-based learning proposed by Park and Shin (2024). The preservice teachers learned basic game elements and functions and then engaged in programming various games tailored to different problem scenarios (Table 3).

In Sessions 1 to 5, learners were introduced to the four stages of the instructional method for game programming developed in this study, along with the MakeCode Arcade platform, basic game elements, and programming techniques. Sessions 6 to 13 followed the four stages of game-based learning. In the Inquiry stage, learners understood the problem scenarios, objectives, and rules for game design. In the Construction stage, they programmed games based on the given problem scenarios. During the Communication stage, the programmed games were connected to the micro:bit Retro Shield hardware and shared with others, with feedback used to identify areas for improvement. In the Expression stage, learners redesigned their games, incorporating the feedback. This cycle was repeated four times. In Sessions 14 and 15, learners designed a game using the four-stage approach that could be applied in a classroom setting, and in Session 16, they presented their final projects. The entire process is visualized in Figure 2.

Table 3. Game-based learning stages

Session	Topic	Activity
1	Game programming and MakeCode Arcade	Understanding game programming and game-based learning stages Understanding the basic structure of MakeCode arcade
2-3	Basics of game programming: sprite, objective, rule	Setting up sprites Defining game Objectives and rules

Session	Topic	Activity
4-5	Basics of game programming: time, reward system, maps	Setting game time Setting a reward system Creating tile maps
6-7	Application game programming - Collecting burgers - Collecting scattered coins	**Inquiry:** Understanding the game story, objective, and rules **Construction:** Programming collecting burgers, collecting scattered coins **Communication:** Share with others using the micro:bit retro shield and improve the game **Expression:** Recreate the game with your own ideas
8-9	Application game programming - Treasure chest maze	**Inquiry:** Understanding the game story, objective, and rules **Construction:** Programming treasure chest maze **Communication:** Share with others using the micro:bit retro shield and improve the game **Expression:** Recreate the game with your own ideas
10-11	Application game programming - Save the earth - Clear the snow	**Inquiry:** Understanding the game story, objective, and rules **Construction:** Programming saves the earth, clear the snow **Communication:** Share with others using the micro:bit retro shield and improve the game **Expression:** Recreate the game with your own ideas
12-13	Application Game Programming - Dodge the Marbles - Jump to the Log	**Inquiry:** Understanding the game story, objective, and rules **Construction:** Programming dodge the marbles, jump to the log **Communication:** Share with others using the micro:bit retro shield and improve the game **Expression:** Recreate the game with your own ideas
14-15	Making a Game	Create a game in four steps
16	Presentation	Game presentation

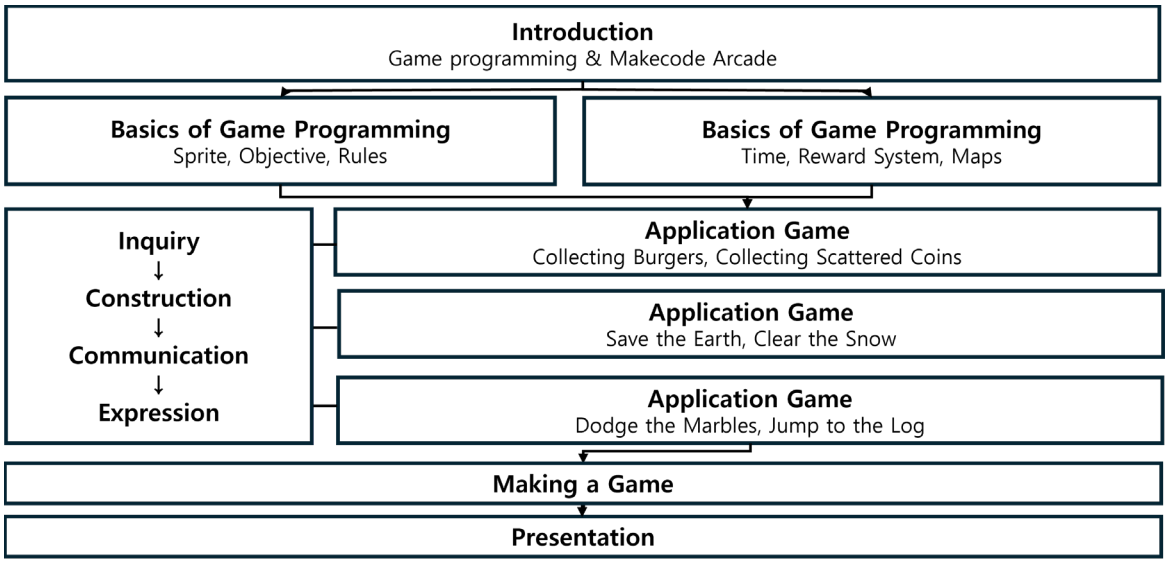

Figure 2. Visualization game-based learning activities

To examine the impact of the program on learning motivation, the Course Interest Survey (CIS) developed by Keller (2010) was administered before Session 1 and after Session 16. The CIS was adopted for this study's context to reflect the theme of game-based learning. For example, the term 'this course' was replaced with 'this game-based learning (GBL) course'. The questionnaire (Table 4) consisted of 34 items representing four motivational dimensions based on the ARCS model: Attention, Relevance, Confidence, and Satisfaction. Each item was rated on a 5-point Likert scale (1 = not true at all, 5 = very true). Items in parentheses indicate reversed items that were reverse-coded prior to analysis.

Table 4. Items from the CIS for Game-based learning

Factors	Item No.	Item Statement
Attention	1	The instructor knows how to make us feel enthusiastic about the subject matter of this GBL course.
	(4)	This class has very little in it that captures my attention.
	10	The instructor creates suspense when building up to a point.
	15	As a student in this class, I am curious about the subject matter.
	21	The instructor does unusual or surprising things that are interesting.
	24	The instructor uses an interesting variety of teaching techniques.
	(26)	I often daydream while in this class.
	29	My curiosity is often stimulated by the questions or problems given in this GBL course.
Relevance	2	The things I am learning in this GBL course will be useful to me.
	5	The instructor makes the subject matter of this GBL course seem important.
	(8)	I do not see how the content of this GBL course relates to anything I already know.
	13	In this class, I try to set and achieve high standards of excellence.
	20	The content of this GBL course relates to my expectations and goals.

Factors	Item No.	Item Statement
	22	The students actively participate in this class.
	23	To accomplish my goals, it is important that I do well in this GBL course.
	(25)	I do not think I will benefit much from this GBL course.
	28	The personal benefits of this GBL course are clear to me.
Confidence	3	I feel confident that I will do well in this GBL course.
	(6)	You have to be lucky to get good grades in this GBL course.
	9	Whether or not I succeed in this GBL course is up to me.
	(11)	The subject matter of this GBL course is just too difficult for me.
	(17)	It is difficult to predict what grade the instructor will give my assignments.
	27	As I am taking this class, I believe that I can succeed if I try hard enough.
	30	I find the challenge level in this GBL course to be about right; neither too easy nor too hard.
	34	I get enough feedback to know how well I am doing.
Satisfaction	(7)	I have to work too hard to succeed in this GBL course.
	12	I feel that this GBL course gives me a lot of satisfaction.
	14	I feel that the grades or other recognition I receive are fair compared to other students.
	16	I enjoy working in this GBL course.
	18	I am pleased with the instructor's evaluations of my work compared to how well I think I have done.
	19	I feel satisfied with what I am getting from this GBL course.
	(31)	I feel rather disappointed with this GBL course.
	32	I feel that I get enough recognition of my work in this GBL course by means of grades, comments, or other feedback.
	33	The amount of work I have to do is appropriate for this type of course.

DATA ANALYSIS

Learning motivation

To examine changes in learning motivation through the game-based learning program, quantitative data were collected using the Course Interest Survey (CIS) developed by Keller (2010). The survey was administered via an online link before and after the intervention. This study employed a within-subjects design and used a paired-samples t-test to compare participants' motivation scores pre- and post-intervention. Statistical analyses were conducted using IBM SPSS Statistics Version 26.0 and JASP.
Due to the small sample size (n=11), this study was exploratory in nature. Accordingly, the findings were interpreted with caution and intended to offer preliminary insights into the impact of game-based learning on preservice teachers' motivation, rather than generalizable conclusions.

Table 5 summarizes the internal consistency of each ARCS subscale. As in Table 4, items in parentheses represent reverse-worded items. Cronbach's α values demonstrated acceptable to high reliability: Attention (α = .722), Relevance (α = .762), Confidence (α = .871), and Satisfaction (α = .889).

Table 5. Reliability of factors in the learning motivation test

Factors	Items	Cronbach's α
Attention	1, (4), 10, 15, 21, 24, (26), 29	0.722
Relevance	2, 5, (8), 13, 20, 22, 23, (25), 28	0.762
Confidence	3, (6), 9, (11), (17), 27, 30, 34	0.871
Satisfaction	(7), 12, 14, 16, 18, 19, (31), 32, 33	0.889

Effect Size

Effect size (ES) is a measure that quantifies the magnitude of the relationship between variables or the impact of a program. While effect size does not inherently imply causality, it is frequently used to describe the degree to which a specific phenomenon occurs (Cohen, 1988). In this study, given the small sample size, the effect size was reported alongside p-values to better capture the magnitude of the intervention's impact beyond statistical significance alone. Cohen's *d*, a standardized measure of effect size based on the mean difference between two groups before and after the intervention, was used for this analysis (Cohen, 1988). Cohen's *d* represents the standardized difference between the means of two groups, calculated by dividing the mean difference by the pooled standard deviation *(s*). s_1^2 and s_2^2 represent the variances of each group.

$$d = \frac{\bar{x}_1 - \bar{x}_2}{s}, \quad s = \sqrt{\frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1 + n_2 - 2}}$$

$$s_1^2 = \frac{1}{n_1 - 1}\sum_{i=1}^{n_1}(x_{1,i} - \bar{x}_1)^2$$

To interpret the effect size on course motivation, this study followed the interpretation criteria proposed by Sawilowsky (2009), which expands upon the standards initially suggested by Cohen (1988). Sawilowsky (2009) recognized the limitations of considering effect size merely as values between 0.2 and 0.8 in Monte Carlo study designs and extended the range of effect sizes from 0.01 to 2. He interpreted effect sizes as follows: Values of *d* between 0.01 and less than 0.2 indicate a very small effect, values between 0.2 and less than 0.5 indicate a small effect, while values between 0.5 and less than 0.8 indicate a medium effect. Values between 0.8 and less than 1.2 indicate a large effect. Values of 2.0 or greater are considered a huge effect.

RESULTS

Table 6 presents the descriptive and inferential statistics, including the paired samples t-test and effect size analysis, on changes in learning motivation through game-based learning for preservice teachers. Statistically significant improvements were found in two of the four motivational factors. Attention showed a statistically significant increase from the pre-test to the post-test, t (10) = -2.854, p<.05, with a very large effect size (d = 1.23). Satisfaction showed a statistically significant increase from pre-test to post-test, t (10) = -2.438, p<.05, with a large effect size (d=0.87). The effect sizes for Attention and Satisfaction were large to very large, suggesting that the intervention had a substantial practical impact on these motivational factors.

Relevance and Confidence showed positive trends, but these changes were not statistically significant. Relevance increased from pre-test to post-test, but the difference was not statistically significant, t (10) = -1.475, p = 0.171, with a medium effect size (d = 0.60). Confidence also increased, but the difference was not statistically significant, t (10) = -1.228, p = 0.248, with a small effect size (d = 0.27).

Table 6. Descriptive and inferential statistics

Factor	Pre-test		Post-test		t	*p*	Cohen's d
	M	SD	M	SD			
Attention	32.55	3.45	36.18	2.41	-2.854	0.017*	1.23
Relevance	39.18	3.79	41.55	4.08	-1.475	0.171	0.60
Confidence	31.73	4.90	33.00	4.60	-1.228	0.248	0.27
Satisfaction	37.18	5.02	41.09	3.96	-2.438	0.035*	0.87

Note. M=mean; SD=standard deviation; *p<.05

As shown in Figure 3, all motivational elements measured in this study tended to increase after the game-based learning classes. This supports the assertion that each subdomain of the ARCS is closely interrelated and that a certain level of improvement across all areas is necessary to stimulate learning motivation (Keller, 1979; Song & Keller, 2001). Among the four components, statistically significant improvements were observed in attention and satisfaction, which are closely related to learners' interest and engagement in class. In the ARCS model, attention refers to the sensory response and selective focus on specific objects within the learning environment. These results suggest that the new learning environment, including the theme of games, topic-centered game design, and the use of physical computing tools, may have positively influenced attention. On the other hand, satisfaction is related to the intrinsic satisfaction felt during the learning process. It can be interpreted that preservice teachers experienced intrinsic motivation and satisfaction by participating as game designers through structured learning activities.

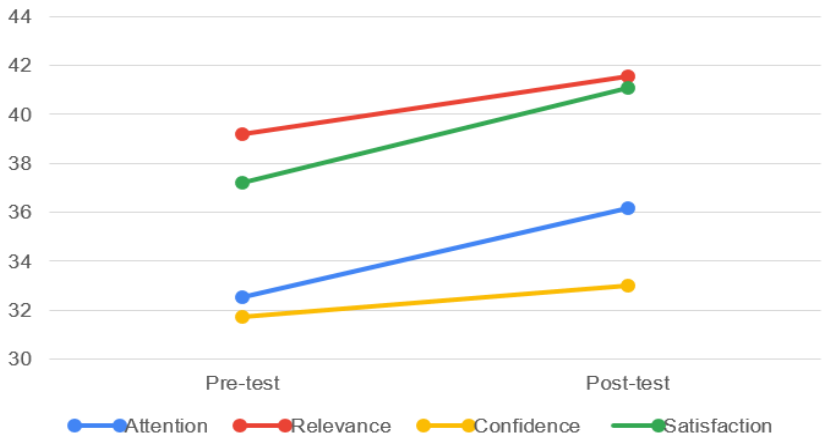

Figure 3. Paired-samples test results

DISCUSSION

This study examined the impact of game-based learning through programming on the learning motivation of preservice teachers. Game-based learning using programming had a positive impact on promoting learning motivation, particularly in terms of attention, relevance, confidence, and satisfaction. Significant improvements were observed in attention and satisfaction, indicating that learners became more immersed in the activities and experienced increased satisfaction with their participation. However, improvements in relevance and confidence were less pronounced, though some positive changes were noted. It is important to recognize that simply stating that game-based learning enhances motivation does not provide a valid rationale for its effectiveness in learning (Whitton, 2007).

More importantly, it is crucial to analyze how games functioned as a learning tool to meaningfully influence preservice teachers' attention and satisfaction, and whether this experience translated into their ability to design game-based learning lessons as future educators.

One possible explanation for the significant results in attention and satisfaction is the integration of programming into the game environment, which provided genuine immersion and engagement within the game context. Rather than merely gamifying learning to stimulate motivation and engagement, this integration offered an authentic and enriching learning experience (Weintrop & Wilensky, 2014). Additionally, systematic, interaction-centered instructional strategies also support learning motivation. This study followed four stages, Inquiry, Construction, Communication, and Expression, based on John Dewey's Four Impulses. During the Communication stage, learners had opportunities to redesign their games multiple times through sharing results and interacting with peers (Park & Shin, 2024). Through this process, learners were able to immediately see how their designs were reflected in the game, which led them to experience a sense of accomplishment and satisfaction. This process not only fostered a sense of accomplishment but may have been aligned with preservice teachers' intrinsic motivation to develop effective and engaging instructional practices. The experience of integrating a game-based environment with a systematically designed instructional approach may have also been connected to their motivation to apply such practices in their future classrooms.

The lack of significant differences in relevance and confidence can be linked to the limitations of this study. First, the goals and themes of the game-based learning activities in this study may not have been directly connected to the preservice teachers' professional and personal situation. Since the activities primarily focused on problem-solving using programming elements, there may have been a lack of connection between the learning content and the participants' real-life contexts. Additionally, the eight-week intervention and small sample size may not have been sufficient to capture changes in these aspects fully. To measure relevance and confidence more precisely, future research should incorporate qualitative data collection and involve a larger sample of participants.

CONCLUSION

This study was conducted with a small sample size of 11 preservice teachers, which limits the generalizability of the findings. Given the limited sample size, this study is more of an exploration study. Despite this, this study provides meaningful insights by highlighting the positive association between the systematic integration of game-based learning and programming instruction and preservice teachers' learning motivation, as well as the potential for developing their instructional design competence to implement game-based lessons in their future teaching practice.

An additional study extending the duration of the intervention would be valuable to determine whether the observed improvements in attention and satisfaction can be sustained over time, and whether relevance and confidence eventually demonstrate more substantial gains. Furthermore, comparative research on various game-based platforms using this instructional design could provide meaningful insights into optimal strategies for effectively integrating game-based learning into programming instruction within teacher preparation programs.

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