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Pre-service teachers' perceptions of integrating digital games into future teaching

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Abstract

This study aimed to investigate pre-service teachers' perceptions of using digital games for future teaching, with a focus on variables including beliefs, motivation to adopt digital games, self-efficacy of digital game integration, and intention to adopt digital games for future teaching. We examined the changes of pre-service teachers' perceptions of adopting digital games over time as well as the relationships of beliefs, motivation, self-efficacy, and intention for the adoption of digital games. Participants included pre-service teachers from a university in the northeastern United States. Quantitative data were collected using online pre- and post-surveys. Quantitative approaches (e.g., t-tests, ANOVAs, etc.) were performed to analyze the data. Results indicated that there were significant changes in pre-service teachers' belief, motivation, self-efficacy, and intention to adopt digital games before and after their participation in a digital game project. Beliefs and motivation were significant predictors of pre-service teachers' intention for future adoption. Gender, iPad ownership, years of playing digital games, and thoughts of using digital games had an influence on pre-service teachers' perceptions of using digital games in future teaching.

Keywords: Digital games, Beliefs, Motivation, Digital game-integration self-efficacy, Intention to adopt digital games, Pre-service teachers

Introduction

There has been an increasing interest of using digital games for learning purposes at different educational levels among teachers or educators (An, 2018; Gutierrez et al., 2023; Kuo et al., 2022). Digital games have the potential to bring about more meaningful learning by providing students with situated learning experiences, just-in-time support, and real-world skills required for future careers (An & Cao, 2017; Engin, 2023). O'Neil et al. (2005) proposed the benefits of using digital games for educational purposes, including

(a) motivation for learning; (b) interactivity; (c) affective and cognitive learning; and (d) complex and diverse methods for learning processes and outcomes.

The term DGBL (Digital game-based learning), created by Prensky (2001), refers to any of the learning activities that apply or use digital games. Van Eck (2015) further explained the definition of DGBL as "the use of games within an existing lesson, classroom, or other instructional contexts where the intent is at least as much to learn rather than to (exclusively) have fun" (p. 144). There are different types of digital games. In general, they can be categorized into games designed for entertainment purposes and games for educational or learning purposes (Shelton & Scoresby, 2011). The line to distinguish these two types of games may be blurring because some games can be used for both purposes (An & Cao, 2017; Hu & Sperling, 2022). Most of the games designed for educational or learning purposes include features such as rewards, drill, practice, or game-like attributes (e.g., fun, fantasy elements, stimulated curiosity) that help to motivate students in the learning process (Shelton & Scoresby, 2011; Mete, 2021). Although empirical studies have shown the potential of DGBL in enhancing student learning, the adoption and implementation of DGBL in K-12 education continue to be perceived as a challenge by teachers and school administrators (Ding et al., 2024). Pre-service and in-service teachers were found to often lack experience, knowledge, skills, or resources to use digital games for instructional purposes in an effective way (Hu & Sperling, 2022).

When integrating technology-based activities into teaching, teachers may encounter several challenges, including time constraints to learn and use new technology, overly complicated technology, limited access to selected technology or technical support, poor teacher training, and schools placing less value on the use of trendy educational technologies (Callaghan et al., 2018; Kenny & McDaniel, 2011). Researchers indicated several factors that hinder teachers from using computer or digital games in the classroom, including inflexibility of curriculum, negative effects of gaming, students' lack of readiness, the lack of supporting materials, fixed class schedules, technology issues, and limited budgets (Baek, 2008; Hu & Sperling, 2022).

Many pre-service teachers do not possess appropriate technological and pedagogical skills required for technology integration into teaching, due to the limited access to relevant tools or resources, or low levels of motivation (Amory, 2011; Hammond et al., 2011). To effectively integrate technologies into teaching, it is critical for pre-service teachers to learn how to select appropriate technology tools in alignment with pedagogies, and use them to teach a specific content (Mishra & Koehler, 2006; Sancar Tokmak & Ozgelen, 2013). Formal instruction and teaching practice are two important ways to provide pre-service teachers with adequate guidance in regard to the essential knowledge and skills for technology integration (Amory, 2011).

Ertmer and Ottenbreit-Leftwich (2010) indicated that teachers change their perceptions of new technologies during or after experiencing or using them through teaching, training, professional development, or other relevant learning opportunities. Involving pre-service teachers in activities or hands-on projects with the use of digital games helps to develop their interests, motivation, confidence, or intention to adopt digital games for teaching (Karadag, 2015). Takeuchi and Vaala (2014) called for the necessity to provide pre-service teachers with formal training on digital game integration, as only 8% of K-8 teachers reported receiving such training on teaching with digital games. Similarly, Karadag (2015) pointed out that the effective use and integration of digital games into instructional processes is dependent on the training or skills that pre-service teachers acquired before entering the teaching career. Eyal et al. (2023) indicated that teaching with digital games is not intuitive for all teachers, and it may require adaptive expertise. For teachers to accept digital games as a valid tool to facilitate teaching and learning, they must fully understand the potential and benefits of using digital games to enhance students' knowledge acquisition and skill development in the content area (Eyal et al., 2023; Hayak & Avidov-Ungar, 2023). This highlights the importance to introduce digital games into pre-service teacher education, and the necessity for teacher educators to place an emphasis on game-based learning (GBL) activities in pre-service teacher education, through which pre-service teachers can be more confident in incorporating digital games into future teaching (Foster & Shah, 2020; Hayak & Avidov-Ungar, 2023; Karadag, 2015).

Many of the previous studies on the application of digital games in teaching focused on the group of in-service teachers (An, 2018; Cantoia et al., 2023; Gutierrez et al., 2023; Hayak & Avidov-Ungar, 2023). Factors that are often used to examine users' perceptions of using technology, such as beliefs, motivation, and self-efficacy, are critical to teachers' intention to adopt or incorporate new technology into the classroom (Ertmer et al., 2012; Kuo et al., 2023). There is limited research on pre-service teachers' perceptions of the use or integration of digital games into future teaching. Moreover, limited empirical studies focused on changes in pre-service teachers' perceptions of digital game use or integration. Of those studies that do examine change, most use qualitative approaches rather than quantitative approaches or research designs suited to how and why these changes occur (Hu & Sperling, 2022; Karadag, 2015; Kennedy-Clark et al., 2011; Sancar Tokmak & Ozgelen, 2013). Therefore, to better prepare pre-service teachers for game-based learning, and to increase our understanding of existing claims about the influence of game-based learning activities on pre-service teachers' perceptions of digital game integration in teacher education contexts, this study investigated pre-service teachers' perceptions of integrating digital games into future teaching through their participation in a digital game project. Specifically, we focused on variables including beliefs, motivation, self-efficacy, and intention to adopt digital games.

Literature review

Digital game-based learning among pre-service teachers

Exposing pre-service teachers to the opportunities or contexts that involve the use of digital games help to shape their knowledge, skills, and disposition towards the integration of digital games in the classroom (Blume, 2019; Foster & Shah, 2020; Johnson & Kim, 2021; Sancar Tokmak & Ozgelen, 2013). Through their experience with digital games in teacher education, pre-service teachers develop a better understanding of the critical role digital games play in facilitating knowledge or skill acquisition, and the potential of using digital games in alignment with pedagogical strategies and subject content (Hu & Sperling, 2022; Romero & Proulx, 2016; Sancar Tokmak, 2015). Based on the relevant literature, there are three major approaches to engaging pre-service teachers in game-based learning: (a) providing game-based learning lessons that allow pre-service teachers to experience learning subject content through the use of digital games (Cozar-Gutierrez & Saez-Lopez, 2016; Hu & Sperling, 2022; Karadag, 2015); (b) designing activities that allow pre-service teachers to explore, select, or evaluate the existing games appropriate for teaching in a subject area (Johnson & Kim, 2021; Kaimara et al., 2022; Kennedy-Clark et al., 2011; Ray & Coulter, 2010; Romero & Proulx, 2016); and (c) involving pre-service teachers in the game design process or game development tasks (Engin, 2023; Sancar Tokmak, 2015; Sancar Tokmak & Ozgelen, 2013).

Course activities and game characteristics are two important factors that affected pre-service teachers' decisions of game integration (Johnson & Kim, 2021; Sancar Tokmak & Ozgelen, 2013). Course activities provide pre-service teachers with opportunities to learn classmates' perspectives through discussion, project-based learning, or reflection activities. The learning philosophy (e.g., behaviorist or constructivist) that a pre-service teacher holds intertwines the factors of course activities and game characteristics (Sancar Tokmak & Ozgelen, 2013). Overall, pre-service teachers value the opportunities of being involved in activities with the use of digital games before starting their teaching career, although some still hold suspecting viewpoints about the use of digital games for learning (Hu & Sperling, 2022; Romero & Proulx, 2016; Sancar Tokmak, 2015). For example, in the study that involved pre-service teachers in an educational game design project, Sancar Tokmak (2015) found that designing educational games improved pre-service teachers' perceptions of TPACK development as they were prompted to concurrently apply all knowledge domains of TPACK in different stages of planning and designing games. Romero and Proulx (2016) investigated pre-service teachers' conceptions about games before being introduced to an activity related to the integration of digital games, and found that most of the pre-service teachers related games to an activity that is fun or relaxing, and educational games to a learning tool that is associated with curricular objectives, or used

for a specific purpose (e.g., assessment, learning support, practice, etc.). Interestingly, very few of them indicated that learning was possible for a game or that educational games could be fun or relaxing. Hu and Sperling (2022) found that pre-service teachers benefited from the use of four digital games (e.g., educational and commercial-off-the-shelf games) through an implementation of a formal lesson.

Teachers' perceptions of technology integration

Research on technology integration in teacher education has indicated that pre-service teachers' beliefs, motivation, and self-efficacy are critical factors that influence their decision or intention to adopt new technology tools in the future classroom (Cullen & Greene, 2011; Ertmer et al., 2012; Kuo & Kuo, 2024). As the use or adoption of digital games has become a new trend in education, it is worthwhile to adopt these factors of technology integration in digital game-based settings, and to further address their importance and relationships in this study.

Beliefs

Teacher beliefs, as one of the most valuable constructs in teacher education, have been studied in different countries (Kim et al., 2013; Lee & Hong, 2024). Beliefs refer to people's subjective judgement about themselves and their environments (Fishbein & Ajzen, 1975). Pajares (1992) indicated that beliefs influence people's decisions and behaviors, and that changes in beliefs result in changes in behaviors. Teachers' belief has a connection with their subsequent planning, pedagogy, and practice (Best, 2017). In the context of technology integration, teachers' beliefs are fundamental to technology acceptance, knowledge acquisition, and effective ways of teaching (Kim et al., 2013; Lee & Hong, 2024). Teachers' beliefs about technology provide information about the value of technology that teachers perceive in teaching and learning. Farjon et al. (2019) further indicated teachers' beliefs towards technology as an important predictor for the acceptance of new technologies in pre-service teacher education. For example, teachers who hold a positive value about the use of technology for instruction are willing to incorporate technology into their teaching or classroom practices (Ertmer et al., 2012).

Self-efficacy

Self-efficacy is another key variable in technology integration (Brianza et al., 2024; Ertmer & Ottenbreit-Leftwich, 2010). Self-efficacy refers to an individual's judgment of his or her ability to accomplish a required task (Bandura, 1977). The concept of self-efficacy is domain specific and has been applied in various disciplines (e.g., information system, psychology, education, etc.) (Kuo & Kuo, 2020; Pintrich & De Groot, 1990). In the context of technology integration for teachers, self-efficacy is regarded as a significant factor in

determining teachers' actual use of technologies in the classroom (Brianza et al., 2024; Ertmer & Ottenbreit-Leftwich, 2010; Lee & Lee, 2014; Simsek & Yazar, 2019). Self-efficacy can be a barrier that hinders teachers from integrating technology into teaching practices (Al-Awidi & Alghazo, 2012). Ertmer and Ottenbreit-Leftwich (2010) stated that merely possessing the knowledge and skills of technology is not enough for teachers to integrate technology, and that teachers' confidence level in what they can do with their technology knowledge and skills is much more important. Some research on pre-service teachers provides evidence to the important role of self-efficacy in pre-service teachers' decision for technology adoption (Al-Awidi & Alghazo, 2012; Kuo & Kuo, 2024; Song, 2018; Wang et al., 2004). Pre-service or novice teachers with high levels of technology integration self-efficacy are more likely to show more enthusiasm and spend more efforts on technology-integrated tasks in their teaching, or to use technology for student-centered learning (Anderson et al., 2011; Kuo et al., 2023; Lee & Lee, 2014).

Motivation

Motivation, as a key construct for understanding human behavior (Ryan & Deci, 2000), refers to the process through which goal-oriented behavior is initiated and sustained (Schunk, 1990). Motivation is an important variable that drives one's selection, persistence, and engagement in particular activities to achieve an objective (Dweck & Elliott, 1983). The concept of motivation generally has been studied in various areas, such as psychology, education, and business (An et al., 2024; Hsieh, 2019; Walker et al., 2024). In the context of technology use or integration, teachers' motivation is considered to be related to their innovative use or adoption of technologies (Sang et al., 2011). Efe and Baysal (2017) claimed that teachers' motivation has an influence on their technology use in education. Motivated teachers have the inspiration to incorporate technologies into their teaching and show continuous usage of technologies on various teaching tasks to enrich students' learning experiences (Beardsley et al., 2020; Efe & Baysal, 2017). Previous researchers further indicated that, in the construct of motivation, it is the level of intrinsic motivation that is self-determined and has a critical impact on whether or not an individual actually performs the action (Pintrich et al., 1993; Venkatesh et al., 2002). Intrinsic motivation for using technologies was found to predict an individual's intention for technology adoption (An et al., 2024; Kim & Keller, 2011; Venkatesh et al., 2002). This study thus intentionally uses intrinsic motivation as it aligns with self-determination theory and as embodied in the technology acceptance model (An et al., 2024; Ryan & Deci, 2000).

Intention to use technology

Intention to use technology refers to the degree to which an individual intends to or would like to use technology in the future (Joo et al., 2018). There is a close relationship between

intention and behavior (An et al., 2024; Kemp et al., 2019; Lee & Hong, 2024). Ajzen (1991) proposed that behavioral intention is the most important variable in predicting one's decision to take an action. Teachers' intention to use technology is regarded as important for explaining their actual use of technology in the classroom (Anderson et al., 2011; Joo et al., 2018; Kuo et al., 2024; Sadaf et al., 2012; Teo & Huang, 2019). Teachers who show a positive intention to use or adopt technology are likely to actually incorporate it into their instruction (Kilinc et al., 2016).

Changes in teachers' perceptions of using digital games

Previous research has indicated the importance of exposing pre-service teachers to a game-based learning environment, and that exploring or playing exiting digital games had a positive impact on pre-service teachers' attitudes of integrating digital games into future teaching (An, 2018; Hu & Sperling, 2022; Kennedy-Clark et al., 2011). For example, Kennedy-Clark et al. (2011) found a positive change in pre-service teachers' attitudes towards the use of digital games in science inquiry after participating in a workshop on game-based learning. Significant shifts were found from negative responses in the pre-test to positive responses in the post-test, specifically for pre-service teachers' perceived value towards educational games, as well as the belief and confidence in their ability to use educational games and integrate them into the classroom.

Similarly, Ray and Coulter (2010) found that pre-service teachers' perceptions of the overall value of digital games as learning tools in middle school classrooms had a significantly positive change after participating in a series of digital mini-games. Specifically, the positive changes were on pre-service teachers' points of views towards the efficacy of digital games to support meaningful learning, instructional practice, and motivation after their participation. Furthermore, Sancar Tokmak and Ozgelen (2013) investigated early childhood education pre-service teachers' perceptions of integrating computer games into their instruction, before and after their participation in a class that involved pre-service teachers in the activities related to selection and redesign of computer games for lesson preparation. The majority of these pre-service teachers changed their decisions of game integration from a behaviorist perspective to a constructivist one. Karadag (2015) indicated that pre-service teachers' knowledge about primary reading and writing was enhanced after participating in game-based learning activities, and that most of the pre-service teachers had positive opinions towards the use of game-based learning scenarios for primary reading and writing instructions.

Research questions

The goal of this research was to investigate pre-service teachers' perceptions of using digital games. We intended to examine pre-service teachers' changes of perceptions

through their participation in the digital game project, as well as the relationships of proposed variables (i.e., beliefs, motivation, self-efficacy, and intention) in pre-service teachers' perceptions. We also explored other personal factors (gender, age, etc.) that may have an influence on teachers' perceptions of using digital games.

1. Do pre-service teachers' perceptions (i.e., beliefs, motivation, self-efficacy, and intention) differ before and after participating in a digital game-based learning project?
2. Do pre-service teachers' beliefs, motivation, self-efficacy, and intention to adopt digital games differ in terms of gender, age, grade levels, iPad ownership, years of playing digital games, and thoughts of using digital games?
3. What are the relationships between pre-service teachers' beliefs, motivation, self-efficacy, and intention to adopt digital games?
4. Do pre-service teachers' beliefs, motivation, and self-efficacy of integrating digital games predict their intention for digital game adoption in future teaching?

Method

Participants

The convenience sampling technique was used for this study. Participants were 97 students enrolled in Educational Technology courses from a northeastern university in the United States (see Table 1). The response rate of the survey was 98%, with two incomplete survey responses removed. The undergraduate-level courses were face-to-face and taught by the same instructor. The undergraduate students were pre-service teachers, with the majority of them in their sophomore or junior year. There were more female (88.4%) than male (11.6%) students. Most participants were 18-21 (72%) years old. About one third reported owning an iPad. All of the students have had the experience of playing digital games, with the majority of them playing digital games for 6-10 (43.6%) or 11-15 (36.2%) years. There were approximately 62.1% of the students thinking about using digital games to develop teaching or learning materials before they attended the Educational Technology class.

Data collection

The study was conducted using an online survey. The online pre- and post-surveys were provided to students at the beginning and the end of the digital game project. The study was approved by the university's Institutional Review Board (IRB), and informed consent forms were obtained from the students who participated in the survey. The survey questionnaire consisted of five sections: Student background information, beliefs, motivation, digital game integration self-efficacy, and intention to adopt digital games (see Table 2). Student background information included gender, age, grade levels, iPad ownership, years of playing digital games, and students' thoughts about using digital games prior to attending the class.

Table 1 Background information of pre-service teachers

Characteristic	*n*	*%*
Gender		
Male	11	11.6
Female	84	88.4
Age		
18-19	28	29.5
20-21	42	44.2
22-23	15	15.8
24 and above	10	10.5
Grade levels		
Freshman	6	6.3
Sophomore	36	37.9
Junior	44	46.3
Senior	9	9.5
iPad ownership		
Yes	36	37.9
No	59	62.1
*Years of playing digital games**		
1-5	11	11.7
6-10	41	43.6
11-15	34	36.2
16-20	8	8.5
Thinking about using digital games before attending the class		
Yes	59	62.1
No	36	37.9

**Note*: The total number of valid responses from 95 participants for "years of playing digital games" is 94, as one participant missed filling out such information.

Table 2 Instruments

Scales	Number of items	Range	Cronbach's alpha
Beliefs	3	1-7	0.86
Motivation	5	1-7	0.94
Digital game integration self-efficacy	16	1-5	0.98
Intention to adopt digital games	3	1-7	0.85

We adopted the scale developed by Hsu et al. (2017) to measure pre-service teachers' beliefs of using digital games in teaching. One of the items, for example, is "Digital games can improve teaching effectiveness." The motivation scale, developed by Shroff and Keyes (2017), was adapted to measure pre-service teachers' perceived interest in applying digital game-based learning activities or tasks for future teaching. One item, for example, is "I feel excited about using digital games for future teaching." The self-efficacy scale of digital game integration was adapted from the instrument developed by Wang et al. (2004) that measured pre-service teachers' technology integration self-efficacy. One item, for example, is "I feel confident I can consistently use digital games in effective ways." The scale measuring pre-service teachers' intention to adopt digital games for teaching was adapted from the instrument developed by Hashim et al. (2015). One item, for example, is "I intend to use digital games for teaching in the future." Beliefs, motivation, and intention for digital game adoption scales are a 7-point Likert scale. The self-efficacy scale of digital game

integration is a 5-point Likert scale. The Cronbach's coefficient alpha values calculated based on the sample of this study (see Table 2) are all above 0.8, indicating reliable measurement of all constructs.

Procedure

Pre-service teachers in the Educational Technology classes participated in a digital game project, in which they were engaged in the development of a lesson plan that incorporated the use of digital games through iPads. The project required students to work in pairs to explore existing digital games that can be used to facilitate learning in a specific content area that they will teach in the future. Students conducted an analysis on the selected games (i.e., providing a summary of selected digital games, including an overview of digital games, the benefits of using digital games in teaching a specific content area, etc.) and developed a lesson plan that integrates digital games that are appropriate for content learning or aligned with the topic of a lesson. The project took 5 weeks to complete. Before the project started, the instructor provided an overview of this project, including the elements required for a lesson plan (e.g., goals, objectives, topics, grade levels, content areas, etc.), project procedures, and related resources about digital games (e.g., useful websites or platforms, successful examples, etc.). During the project, the instructor served as a facilitator to assist students who encountered difficulties or problems when they explored content-related digital games or developed the lesson plan. At the end of the project, students shared their project with classmates through presentation in class.

Data analysis

Data were analyzed using quantitative approaches. Quantitative approaches included descriptive analyses, T-tests, ANOVAs, and correlation and regression analyses. SPSS 28 was used for data analyses. Normality of the data and homogeneity of variance were examined. With the absolute value of skewness and kurtosis smaller than 1.96, normality of data distribution was acceptable. Dependent T-tests were performed to answer research question one. ANOVAs were performed to answer research question two. Pearson's correlation analyses were conducted to answer research question three about the relationships of pre-service teachers' belief, motivation, self-efficacy, and intention to adopt digital games. A multiple regression analysis was performed to answer research question four about the prediction of three proposed variables on intention to adopt digital games.

Results

This section includes information about the results of data analysis for research questions proposed in this study.

RQ1: Do pre-service teachers' perceptions (i.e., beliefs, motivation, self-efficacy, and intention) differ before and after participating in a digital game-based learning project?

T-test analyses in Table 3 show the changes of scores of pre-service teachers' perceptions of adopting digital games for future teaching before and after they participated in the digital game project. There was an increase of the average scores from pre- to post-surveys on pre-service teachers' perceptions of adopting digital games. Pre-service teachers' beliefs (t = -8.29, p < .001) and motivation (t = -9.60, p < .001) about using digital games in their future teaching increased significantly after their participation in the project. Similarly, positive changes were found at a significant level on pre-service teachers' self-efficacy of integrating digital games (t = -9.23, p < .001) and their intention to adopt digital games (t = -9.51, p < .001). The effect sizes were large, ranging from 0.84 to 0.99 (see Table 3).

RQ2: Do pre-service teachers' beliefs, motivation, digital game integration self-efficacy, and intention to adopt digital games differ in terms of gender, age, grade levels, iPad ownership, years of playing digital games, and thoughts of using digital games?

According to ANOVA analyses in Table 4, gender had a significant influence on pre-service teachers' beliefs of using digital games (F = 5.53, p < .05) and intention to adopt digital games (F = 4.01, p < .05). Age (see Table 5) and grade levels (see Table 6) did not significantly influence pre-service teachers' perceptions of using or adopting digital games. iPad ownership (see Table 7) had a significant impact on digital game integration self-efficacy (F = 5.53, p < .05) and intention to adopt digital games (F = 5.53, p < .05). Pre-service teachers who owned an iPad had a significantly higher level of self-efficacy (M_{yes} = 4.63; M_{no} = 4.38) and intention to adopt digital games (M_{yes} = 6.36; M_{no} = 6.03), compared to those who did not own an iPad.

Table 3 T-test analysis for pre- and post-scores in beliefs, motivation, digital game integration self-efficacy, and intention to adopt digital games

	Pre		Post				
	M	SD	M	SD	*t(94)*	*p*	Cohen's *d*
Beliefs	5.21	0.93	6.14	0.76	-8.29	.000***	0.84
Motivation	4.99	1.16	6.18	0.82	-9.60	.000***	0.99
Digital game integration self-efficacy	3.83	0.60	4.47	0.51	-9.23	.000***	0.96
Intention to adopt digital games	5.04	1.16	6.15	0.73	-9.51	.000***	0.85

Note. ***p < .001

Table 4 ANOVA analysis for gender and proposed variables

	Males		Females		
	M	SD	M	SD	*F*
Beliefs	5.67	0.89	6.23	0.72	5.53*
Motivation	6.07	0.81	6.20	0.82	0.27
Digital game integration self-efficacy	4.33	0.38	4.51	0.50	1.29
Intention to adopt digital games	5.76	0.76	6.22	0.71	4.01*

Note. *$p < .05$.

Table 5 ANOVA analysis for age and proposed variables

	18-19		20-21		22-23		24 and above		
	M	SD	M	SD	M	SD	M	SD	*F*
Beliefs	6.30	0.79	6.05	0.64	6.11	0.94	6.23	0.90	0.66
Motivation	6.33	0.83	5.99	0.80	6.27	0.80	6.44	0.86	1.44
Digital game integration self-efficacy	4.53	0.54	4.37	0.52	4.62	0.44	4.55	0.48	1.18
Intention to adopt digital games	6.31	0.74	6.06	0.67	6.20	0.87	6.03	0.81	0.75

Note. Self-efficacy refers to digital game integration self-efficacy. Intention refers to intention to adopt digital games.

Table 6 ANOVA analysis for grade levels and proposed variables

	Freshman		Sophomore		Junior		Senior		
	M	SD	M	SD	M	SD	M	SD	*F*
Beliefs	6.28	0.83	6.15	0.83	6.09	0.73	6.37	0.70	0.39
Motivation	6.20	0.99	6.19	0.81	6.09	0.86	6.56	0.53	0.79
Digital game integration self-efficacy	4.46	0.55	4.46	0.53	4.44	0.53	4.68	0.38	0.54
Intention to adopt digital games	6.44	0.62	6.13	0.77	6.04	0.73	6.63	0.48	2.03

Note. Self-efficacy refers to digital game integration self-efficacy. Intention refers to intention to adopt digital games.

Table 7 ANOVA analysis for iPad ownership and proposed variables

	Yes		No		
	M	SD	M	SD	*F*
Beliefs	6.29	0.73	6.06	0.78	2.16
Motivation	6.35	0.75	6.08	0.85	2.47
Digital game integration self-efficacy	4.63	0.54	4.38	0.53	5.81*
Intention to adopt digital games	6.36	0.72	6.03	0.72	4.81*

Note. *$p < .05$.

Table 8 ANOVA analysis for years of playing digital games and proposed variables

	1-5		6-10		11-15		16-20		
	M	SD	M	SD	M	SD	M	SD	*F*
Beliefs	6.12	0.48	6.32	0.67	6.04	0.90	5.89	0.90	1.25
Motivation	6.03	0.67	6.46	0.61	6.05	0.95	5.60	1.00	3.71*
Self-efficacy	4.11	0.40	4.65	0.46	4.43	0.50	4.29	0.66	4.40**
Intention	6.20	0.60	6.34	0.60	6.01	0.84	5.78	0.88	2.19

Note. *$p < .05$; **$p < .01$ Self-efficacy refers to digital game integration self-efficacy. Intention refers to intention to adopt digital games.

Table 9 ANOVA analysis for thoughts of using digital games and proposed variables

	Yes		No		
	M	SD	M	SD	*F*
Beliefs	6.23	0.71	6.04	0.83	1.34
Motivation	6.31	0.77	6.01	0.87	3.15
Digital game integration self-efficacy	4.49	0.51	4.48	0.47	0.01
Intention to adopt digital games	6.29	0.66	5.96	0.80	4.62*

Note. *$p < .05$.

Table 8 shows that pre-service teachers' experience of playing digital games significantly influenced their motivation to use digital games ($F = 3.71$, $p < .05$) and self-efficacy in integrating digital games ($F = 4.40$, $p < .01$). Post Hoc analyses showed that pre-service teachers who had played digital games for 6-10 years had more positive beliefs in using digital games than those who had played digital games for 16-20 years at a significant level ($p = 0.206$). Pre-service teachers who had played digital games for 6-10 years had a higher level of digital game integration self-efficacy than those having played digital games for 1-5 years ($p = 0.008$).

Table 9 shows that pre-service teachers who thought about using digital games to develop teaching or learning materials had a higher level of intention to adopt digital games for future teaching than those who did not think about using digital games ($F = 4.62$, $p < .05$). For pre-service teachers' beliefs ($F = 1.34$, $p > .05$), motivation ($F = 3.15$, $p > .05$), and digital game integration self-efficacy ($F = 0.01$, $p > .05$), the mean differences of these two groups of pre-service teachers were not significant.

RQ3: What are the relationships between pre-service teachers' beliefs, motivation, self-efficacy, and intention to adopt digital games?

Table 10 shows the correlations among beliefs, motivation, digital game integration self-efficacy, and intention for digital game adoption. All correlations were positive and significant at a p-value of 0.01. Beliefs ($r = .79$, $p < .01$), motivation ($r = .78$, $p < .01$), and

Table 10 Correlations among variables

	Beliefs	Motivation	Digital games integration self-efficacy	Intention to adopt digital games
Beliefs	-	.78**	.66**	.79**
Motivation		-	.70**	.78**
Digital game integration self-efficacy			-	.66**
Intention to adopt digital games				-

Note. **$p < .01$.

Table 11 Multiple regression model: intention to adopt digital games explained by three predictor variables

Variables	*B*	*SE B*	β	*t*	*p*
Beliefs	.473	.087	.492	5.456	.000***
Motivation	.297	.084	.332	3.529	.001**
Digital games integration self-efficacy	.146	.111	.102	1.312	.193

Note. **$p < .01$; ***$p < .001$

digital game integration self-efficacy ($r = .66$, $p < .01$) were positively related to intention to adopt digital games. The strongest correlation was found between beliefs and intention to adopt digital games ($r = .79$, $p < .01$).

RQ4: Do pre-service teachers' beliefs, motivation, and self-efficacy of integrating digital games predict their intention for digital game adoption in future teaching?

The multiple regression model (see Table 11) was significant, F (3, 92) = 84.3, $p < .001$. The model explained 73.3% of the variance in intention to adopt digital games. Among the three independent variables, belief ($t = 5.456$, $p < .001$) and motivation ($t = 3.529$, $p < .01$) significantly predicted intention to adopt digital games. Self-efficacy in integrating digital games ($t = 1.312$, $p > .05$) did not significantly predict intention for digital game adoption. Within the two significant predictors, teachers' belief was the strongest predictor for intention to adopt digital games.

Discussion

Pre-service teachers' perceptions of using and adopting digital games for future teaching increased after participating in the digital game project

Through pre- and post-surveys, the results showed that there were positive changes in pre-service teachers' perceptions of using and adopting digital games in the future

classroom. After participating in the digital game project, pre-service teachers' beliefs, motivation, self-efficacy, and intention to use and adopt digital games in future teaching increased significantly. This finding, in line with the prior research about the positive impact of exploring digital games on teachers' use of digital games (An, 2018; Hu & Sperling, 2022), suggested that engaging pre-service teachers in the activities or projects that incorporate the use of digital games is beneficial to improve their confidence and willingness to adopt digital games for teaching, and develop their positive beliefs and motivation towards the use of digital games. Furthermore, such a finding supports the claim by Ertmer and Ottenbreit-Leftwich (2010) that hands-on activities may benefit pre-service teachers by changing pre-service teachers' knowledge, skills, or attitudes with regard to technology use or adoption in instruction. Furthermore, this finding confirms the necessity to provide pre-service teachers with learning opportunities or hands-on activities with digital games to enhance their confidence to adopt digital games in teaching (Eyal et al., 2023; Hayak & Avidov-Ungar, 2023). These results also add to the existing qualitative findings (Karadag, 2015; Kennedy-Clark et al., 2011; Tokmak & Ozgelen, 2013) on the growth of pre-service teachers' perceptions of using or integrating digital games into teaching through game-based learning activities.

Gender, iPad ownership, years of playing digital games, and thoughts of using digital games had a significant effect on pre-service teachers' perceptions of integrating digital games for future teaching

Gender, iPad ownership, years of playing digital games, and thoughts about the use of digital games appeared to have an impact on pre-service teachers' perceptions of digital game use and adoption. Overall, compared to male pre-service teachers, female pre-service teachers held more positive beliefs about the use of digital games for instruction, and higher levels of intention to adopt digital games. This result contradicts the finding of the research from Alkan and Mertol (2019) in which male teacher candidates were found to be more positive about the use of digital games than female teacher candidates in Turkey. Pre-service teachers who owned an iPad were more likely to have higher levels of self-efficacy and intention to integrate or adopt digital games in future teaching, compared to those who did not have an iPad. This makes sense because pre-service teachers who owned an iPad had more chances to explore digital games provided through iPads, which leads to higher levels of self-efficacy and intention for digital game adoption. This finding supports the crucial role of device ownership in the use and integration of new technologies in curriculum design and delivery (Aheto & Cronje, 2019; Kuo et al., 2023).

Pre-service teacher's prior experience of playing digital games had an impact on their motivation and intention to incorporate digital games into teaching. This finding is in line with previous studies where teachers' positive attitudes towards digital game-based

learning were found to be correlated with their prior experience with digital games (Blume, 2019; Chik, 2011). Teachers' receptivity towards digital games is believed to be shaped by their prior experience with gaming (Chik, 2011). Pre-service teachers who had thought about the use of digital games for instruction were more willing to adopt digital games for future teaching, in comparison to those who had never thought about using digital games for teaching purposes. This finding makes sense and implies that pre-service teachers who have been thinking about or generating the idea of the use of digital games in teaching and learning are more likely to show higher levels of intention of digital game adoption for future teaching, compared to their counterparts.

Beliefs and motivation significantly predicted intention to adopt digital games

Positive correlations were found among the proposed four variables that addressed pre-service teachers' perceptions of using or adopting digital games. Beliefs, motivation, and digital game integration self-efficacy had a significantly positive relationship with the intention to adopt digital games. Beliefs and motivation were significant predictors of intention to adopt digital games, which implies that pre-service teachers who were more positive about the use of digital games, or had a higher level of motivation to incorporate digital games into teaching, were more likely to show the willingness to adopt digital games in their future teaching. This result supports the claim proposed by Efe and Baysal (2017) and prior research findings from An et al. (2024), Kim (2011) and Venkatesh et al. (2002) about the critical role of teachers' motivation in predicting their intention for technology adoption.

Interestingly, self-efficacy in integrating digital games was not found to significantly predict intention for adopting digital games for pre-service teachers. The result contradicts the findings of previous studies where technology integration self-efficacy was found to be critical in determining pre-service teachers' intention for future technology adoption (Al-Awidi & Alghazo, 2012; Song, 2018). It may be due to the differences of average scores on self-efficacy among pre-service teachers were not sensitive enough to reveal the full range of possible scores.

Conclusion, limitations, and implications

This study investigated pre-service teachers' perceptions towards the use of digital games in future teaching. The results of this study have increased the understanding of pre-service teachers' perceptions of using digital games for future teaching, specifically on the factors including beliefs, motivation, self-efficacy of digital game integration, and intention to adopt digital games. This study not only adds to the limited research on the change of perceptions of adopting digital games in pre-service teacher contexts, but also provides insights into the impact of beliefs, motivation, and self-efficacy on pre-service teachers'

intention for digital game adoption. Pre-service teachers' participation in the digital game project contributed to a significant change in their beliefs, motivation, self-efficacy of digital game integration, and intention for digital game adoption. Pre-service teachers' beliefs and motivation towards the use of digital games were found to be significant predictors of their intention for future digital game adoption. In addition, factors such as gender, iPad ownership, years of playing digital games, and thoughts of using digital games were found to have a potential impact on pre-service teachers' perceptions of using digital games for future teaching. These results have confirmed the importance of providing pre-service teachers with hands-on, digital game-based activities or projects to shape their understanding of the potential of digital games in enhancing learning, and to increase their positive viewpoints, motivation, confidence, and willingness about the use of digital games as instructional tools for future teaching.

In terms of the limitations of this study and implications for future research, the results of this study may not be generalized to other groups of pre-service teachers in different countries. Our study involved pre-service teachers who would teach in different subject areas and at different grade levels (elementary, middle, or high schools), which may not be replicated in other contexts. Future researchers should consider the potential influence of subject areas and grade levels, and determine whether the context of this study could be replicated with different groups (e.g., including different disciplines, different countries or cultural backgrounds, etc.) of pre-service teachers to validate the findings of this study. Moreover, the instruments used in this study need further validation, and we suggest that researchers apply these instruments to further examine the relationships of proposed variables of perceptions of digital game use or adoption. Exploring additional motivation constructs may be useful, alongside the direct and indirect relationships with both behavioral intentions to use and actual adoption of digital games in the classroom. In addition, project design (e.g., the length of a project, collaborative or individual work, etc.) may play a role in examining pre-service teachers' perceptions of digital game use. This study engaged pre-service teachers in a 5-week long project, and a project design with more than 5 weeks would allow pre-service teachers more time to explore digital games. The variables that were not explored in this study, such as course design, instructor's efforts, etc., may have an influence on pre-service teachers' perceptions of digital game adoption, and future research should consider including them in the investigation.

In terms of practical implications, this study suggests that teacher educators should (a) provide pre-service teachers with opportunities to participate in learning activities or teaching practices with the use of digital games that help to enhance their beliefs, motivation, self-efficacy, and intention for future digital game use or adoption; (b) design learning activities or projects that allow pre-service teachers to gain personal experiences by exploring available digital games and developing their own lessons or materials using

appropriate digital games in the subject area that they will teach; (c) share best practices and successful examples on the integration of digital games in teaching and learning to develop pre-service teachers' positive beliefs of the use of digital games in enhancing teaching or learning effectiveness; (d) provide pre-service teachers with opportunities to reflect on their experiences of using digital games in teaching and learning; and (e) offer pre-service teachers the devices (e.g., iPads, computers, etc.) needed for exploring and playing digital games for teaching or learning purposes. In addition, resource availability at K-12 schools (e.g., technology access or availability), school support (e.g., financial or technical support), and pedagogical strategies (e.g., project-based learning, collaborative learning, etc.) may have an influence on pre-service teachers' perceptions of adopting digital games for teaching. Furthermore, the hands-on project of digital games may have a long-term impact on pre-service teachers' use of digital games. Pre-service teachers with positive perceptions towards the use of digital games in teaching, may be more likely to be persistent in adopting digital games in future teaching, and show interests in participating in future professional development opportunities with topics on digital games.

Abbreviations
DGBL: Digital game-based learning; GBL: Game-based learning.

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The authors are responsible for the whole manuscript.

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