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Abstract

The purpose of this exploratory study was to examine whether specific attitudes and beliefs among pre-service teachers about the use of computer games in mathematics teaching and learning predict their intention to integrate computer games in future mathematics teaching. Data were collected via a questionnaire from 119 teacher education students in a mathematics methods class at a midwestern USA university. Findings indicate that previous experience of computer gaming, gamer identity, self-efficacy for computer game-based teaching, perceived educational benefits of computer games, and gender stereotypes about computer gaming were significantly related to intention to integrate computer games in future teaching. Multi-level linear regression analysis indicates that self-efficacy, perceived benefits and gender stereotypes did not explain significantly more variance in intention for game integration above and beyond that explained by previous experience of computer gaming and gamer identity. Gender and specialization of the preservice teachers were related to previous experience of computer gaming and gamer identity. The results and educational implications of the study for teacher education and policy making are discussed and limitations of the study are addressed.

Introduction

Previous research has consistently found that U.S. students perform less well in mathematics than their peers in many other countries (Greene & McGee, 2012). According to the recent assessments of approximately 540,000 15-year-old students that participated in the 2015 study of the Program for International Student Assessment (PISA), the U.S. ranked just 38th among the 72 participating countries and economies and an unimpressive 30th among the 35 member countries of PISA's sponsoring organization (OECD, 2018). It is believed that such a lack of mathematics proficiency will make it increasingly difficult for U.S. high school and college graduates to compete for jobs in the global marketplace (Schmidt, 2012; Suter & Camilli, 2019). Researchers and educators are seeking innovative instructional approaches to improve math achievement and motivation among K-12 students.

In recent years, computer and video games have been increasingly advocated as an effective instructional tool for engaging students in mathematics learning (Ku, Chen, Wu, Lao, & Chan, 2014). Though originally played on electronic consoles connected to a TV screen, video games are considered synonymous with computer games today since 21st century consoles have evolved to have as much information processing and Internet capabilities as computer devices (Chikhani, 2015). Computer and video games are "an integral part of American culture", with three quarters of Americans having at least one gamer in their households and game sales reaching a record $43 billions in 2018 (ESA, 2019).

When games are developed or adapted for educational use, they are called serious games or game-based learning (GBL) environments. GBL is an emerging paradigm for instructional innovations across all disciplines and educational levels. New technologies such as mobile learning, virtual reality and artificial intelligence continue to be integrated into the design of GBL environments. In their comprehensive review of GBL research, Granic, Lobel, and Engels (2014) summarized its many cognitive, motivational, emotional, and social benefits and argued that these benefits may generalize to contexts outside games.

Computer Games in K-12 Education

There is much evidence in previous studies that compared to traditional methods of instruction, the use of digital or computer games tends to be associated with better achievement and more positive attitudes towards learning among the students (Tobias, Fletcher, Dai, & Wind, 2011). Researchers in mathematics education also report positive findings regarding the effectiveness of computer games. In an experimental study, Kebritchi (2008) examined the effect of computer games on mathematics achievement and motivation among high school students. The findings indicated that students in the experiment group had higher mathematics achievement than those in the control group, though there was no significant difference in student motivation for mathematics learning. In another experimental study, Riconscente (2013) investigated whether an iPad fractions game, Motion Math, would improve fourth graders' knowledge of fractions and their math attitudes.

Findings indicated that the experimental group significantly outperformed the control group in both achievement and attitudes. After playing Motion Math for 20 minutes daily over a 5-day period, the experimental group's fractions test scores improved an average of 15% and their self-efficacy for fractions and liking of fractions improved an average of 10%. Ke, Clark, and Uysal (2019) engaged 56 middle school students in playing an architecture-themed simulation-based mathematics problem solving game named E-Rebuild. Their findings indicate positive effects of gameplay on the students' math problem representation and solution, math test scores, and mental rotation task performance.

Although there are quite a few experimental studies that indicate positive effects of computer games on students' math achievement and math attitudes, consensus is yet to be reached (Kim & Chang, 2010). In an experimental study of 4th and 5th graders, Ke (2008) found that significant effect of computer gaming on students' learning attitudes but not on their test performance. Ke (2008) examined the impact of web-based educational games and classroom goal structures on fifth graders' mathematics learning outcomes. She used four computer games developed with the purpose of increasing problem-solving and decision-making skills. She found that cooperative goal structure was more effective in enhancing learning motivation whereas individualistic goal structure seemed to be more effective in promoting learning gains. Nevertheless, the effect on math achievement was not statistically significant.

Research findings indicate that factors such as gender, English Language Learners (ELL), and type of games may play a role on students' performance in mathematics. For example, Kim and Chang (2010) empirically examined the effects of playing computer games on mathematics achievement of 4th graders with special focus on gender and language minority groups. The study found a gender-based differential effect of computer games on math achievement with the computer game significantly associated with male students' mathematics achievement but not with female students' achievement. They found that when males played computer games less frequently, they demonstrated higher performance than those who did not play at all. However, males showed low performance when they played computer games too frequently. The study also found a differential effect on two linguistic groups with English-speaking males showing low math achievement scores with daily mathematics games while ELL male students demonstrated high achievement. Ku et al. (2014) found that low ability students showed higher mathematical gains among fourth grade students. The type of the educational game can influence cognitive gains. Majority of schools tend to use drill-and-practice games. Papert (1998), Kiili (2005), and Gee (2005) emphasized that open-ended, exploratory, user-guided games are superior for learning, and linear, drill-and-practice games are of little value as educational tools (as cited in Dedeaux & Hartsell, 2018).

Computer Games in Teacher Education

Teacher preparation programs may need to revisit curricula in order to integrate pedagogically sound, standards and research-based digital game integration. A national study of in-service K-8 teachers (Millstone, 2012) indicates that teacher education programs have done poorly in terms of preparing preservice teachers for taking advantage of the potential of digital games. Most of the surveyed teachers first learned about digital games during in-service professional development (46%) or through self-study (35%). Only 12% of them did it during pre-service education. In-service teachers also tended to use games for literacy or reading more (50%) than they did for mathematics (35%). A study by Ruggiero (2013) sought to examine both teachers' perceptions of gaming in the classroom. Findings from this study revealed that gaming is a good use of technology for engaging and motivating students. However the study also found that less than half of the in-service teachers use gaming in their teaching while over 75% of pre-service teachers said they would like to know more about using games in the classroom. A majority of teachers felt that gaming the classroom was a value-add to students and should be used in certain situations such as classroom demonstrations or for special needs students.

In a study by Demirbileka and Tamerb (2010) investigating the perspectives of mathematics teachers on utilizing educational computer games in mathematics education, teachers mentioned some problems related to using games in the classroom including problems in classroom management and deviation from the goal of the lesson. The researchers also found that there were discrepancies in teacher beliefs. While teachers think that there is limited educational potential of computer games, they also believe that computer games may have positive effects on mathematics learning. Callaghan, Long, Van Es, Reich and Rutherford (2018) conducted a study to understand how teachers integrated games into their instruction and how those teaching practices are associated with student achievement. In their findings, teachers felt they would strongly benefit from professional development support that provided opportunities to play the game with an experienced person, which would enable them to learn how to use game features and strategies for helping students and integrating the game into their teaching. Some teachers were unaware of the game's purpose and underlying mathematics. They expressed challenges aligning the game with their curriculum. The mathematics game and in-class lessons were seen as separate entities rather than blended form of teaching the same content. Such findings point out an urgent need for teacher educators to provide sufficient training in order to equip preservice teachers with the motivation, knowledge and skills for integrating the use of digital games in their teaching practice.

Meletiou-Mavrotheris and Prodromou (2016) in a study in which participants experimented with different ways in which educational games could help students internalize key mathematical concepts found that that there was a positive impact on pre-service teachers' perceptions regarding game-based learning, and on their competence in selecting, evaluating, and productively utilizing digital games as an instructional tool. A study by Vu, Fredrickson, Hoehner and Ziebarth-Bovil (2016) examined pre-service teachers' attitudes toward game-based learning. The research results showed that pre-service teachers enjoyed playing games integrated into the course. They spent time playing the games and found them enjoyable and useful. Playing games helped them focus on the topic and review what they had learned from the lecture. The participants valued the usefulness of integrating games into the classroom. They also indicated that they would integrate games into their teaching.

Purpose of Study

The purpose of this exploratory study was to examine whether specific attitudes and beliefs among pre-service teachers about the use of computer games in mathematics teaching and learning predict their intention to integrate computer games in their future mathematics teaching. We also explore the role of gender and specialization area of the teacher education program of the preservice teachers. Based on a review of previous literature, we included the following predicting variables: previous experiences with computer gaming, attitude toward computer gaming, gender stereotypes about computer gaming, perceived benefits and perceived barriers to educational use of computer games, and teacher self-efficacy for incorporating computer game-based learning in a mathematics class. Our hypothesis is that pre-service teachers who are more likely to use computer games in future mathematics teaching tend to

a) have more advanced computer gaming experience in and out of the classroom,
b) have more positive attitudes towards computer gaming,
c) hold fewer gender stereotypes about computer gaming,
d) believe in educational benefits of computer games,
e) see fewer barriers to educational use of computer games, and
f) be more self-efficacious about using computer games in a mathematics class.

Method

Participants

The participants were undergraduate preservice teachers enrolled in a mathematics methods course at a mid-western university over two semesters. A total of 117 valid responses to the survey were received, including 19 males and 98 females. In terms of teacher education specialization, the sample consisted of 79 early and middle childhood education majors and 38 special education majors.

Measures

The researchers developed the Attitudes towards Computer Games in Mathematics Teaching Questionnaire. The questionnaire has three sections. The first section consists of questions about gender, age, concentration of teaching degree, and previous experience with computer gaming. Regarding computer gaming experience, participants are asked to check as many types of computer games that they have played in previous experiences as applicable, including: no experience at all, standalone games, online games, and multi-player online games.
The second section consists of a scale on gamer identity, and four subscales on self-efficacy, perceived benefits, perceived barriers, and gender stereotypes regarding the integration of computer games in mathematics education. Participants were asked to rate each statement on a 5-point Likert-type scale that ranges from 1 (strongly disagree) to 5 (strongly agree).

Gamer identity. This scale was developed by Bourgonjon, Valcke, Soetaert, and Schellens, (2010). It includes five statements. Example items are “I like playing computer games” and “I would describe myself as a gamer”. Although Bouorgonjon et al., called this scale experience with games, it is more about the extent to which an individual identifies with being a computer gamer than it is about the actual amount of gaming experience. The scale has a Cronbach’s alpha of .92.

Self-efficacy for computer game integration in mathematics education. The self-efficacy subscale was developed by Authors, (2018). It consists of 14 items, each a specific task of integrating computer games in a mathematics classroom. Example items are “find appropriate educational games for use in my math classroom” and “align the use of computer games with specific course content or objectives in math”. Participants were asked to rate their confidence for completing each task using a 5-point Likert-type scale that ranges from 1 (no confidence at all) to 5 (complete confidence). The scale has a Cronbach’s alpha of .94.

Perceived benefits of computer game integration in mathematics education. The perceived benefits subscale was developed by adapting a subset of statements in the Teacher Attitudes about Digital Games in the Classroom Survey (Millstone, 2012) to fit the context of mathematics education and supplementing with statements about additional benefits that were mentioned in the findings of previous studies. Participants were asked to rate the extent to which they agree with a list of possible benefits of using computer games in a mathematics classroom. Example items are “make math learning more fun and enjoyable” and “help to engage students of different ability levels.” The scale has a Cronbach’s alpha of .92.

Perceived barriers to computer game integration in mathematics education. The perceived barriers subscale was developed by adapting a subset of statements in the Teacher Attitudes about Digital Games in the Classroom Survey (Millstone, 2012) to fit the context of mathematics education and supplementing with statements about additional barriers that were mentioned in the findings of previous studies. Participants are asked to rate the extent to which they agree with a list of potential difficulties and challenges with using computer games in a mathematics classroom. Example items are "lack of funds to cover technological costs related to game purchase, installation, and upgrading" and "technical issues (hardware, software, or network) that can occur during game playing." The scale has a Cronbach's alpha of .87.

Gender stereotypes about computer gamers. The gender stereotypes scale was developed by Authors, (2018). Participants are asked to rate the extent to which they agree with a list of gender stereotypes regarding the confidence, competence, and motivation for playing computer games among boys and girls. Example items are "Boys are more confident about their ability to play and win computer games than girls."; "Boys can identify with characters in computer games more than girls." The scale has a Cronbach's alpha of .96.

The last section of the questionnaire includes one question about preservice teachers' intention for integrating the use of computer games in future mathematics teaching. Participants are asked to rate how likely or unlikely they would do so on a four-point scale. This section also contains open-ended questions about the pros and cons of integrating computer gaming in mathematics education.

Results

A total of 119 questionnaires were returned. We excluded two submissions, one with missing values for an entire page and the other with identical values for all questions on one of the subscales. For the eight submissions that skipped a few items randomly, we substituted the missing values with the mean. For those who checked two consecutive points on a scale, we used the middle point in our data analysis. After data cleaning, the total number of valid responses was 117.

Results of Quantitative Data Analysis

Both descriptive and inferential statistical analyses were conducted. We first explored the correlations among the key variables measured in the survey. As shown in Table 1, computer gaming experience was positively related to attitudes towards computer gaming. Both gaming experience and attitude were positively related to self-efficacy and intention for integrating computer games in a mathematics classroom, and both were negatively related to gender stereotypes about computer games. Whereas gaming experience was unrelated to perceived benefits of or barriers to computer game-based education, attitude was positively related to perceived benefits but unrelated to perceived barriers. Self-efficacy was positively related to gaming experience, attitudes, perceived benefits, and intention for integrating computer games in teaching, but unrelated to either perceived barriers or gender stereotypes.

Table 1. Bi-variable Pearson's Correlation Coefficients among Continuous Variables

Variables	1	2	3	4	5	6	7
1. Gaming experience	---						
2. Gamer identity	**.46****	---					
3. Self-efficacy	**.30****	**.35****	---				
4. Perceived benefits	.06	**.22***	**.59****	---			
5. Perceived barriers	-.09	-.03	-.06	-.11	---		
6. Gender stereotypes	**-.25****	**-.30****	-.18	-.14	**.19***	---	
7. Future intention	**.29****	**.38****	**.30****	**.35****	-.12	**-.28****	---

Note. * $p < .05$. ** $p < .01$.

Gender Differences

We explored gender differences in computer gaming experience. As shown in the frequencies cross tabulated in Table 2, male and female preservice teachers reported different levels of computer gaming experience. None of the males reported no-gaming experience, while 14 (14.3%) of the females reported no-gaming experience. Males reported more diverse gaming experience that tended to include multi-player online gaming experience (73.7% vs. 42.8%) than females, whereas females were more likely to report that they had experience with standalone and/or online games but not multi-player online games (42.8% vs. 26.4%). Chi-square test indicated that there is a significant relationship between gender and computer gaming experience, χ^2 (5, N = 117) = 12.077, p = .034. Compared to female preservice teachers, male preservice teachers are less likely to have had no experience at all in computer gaming and more likely to have had advanced computer gaming experience such as multi-player online gaming experience

Table 2. Gender Differences in Computer Gaming Experience

Gaming Experience	Gender		
	Male (n = 19)	Female (n = 98)	Combined (n = 117)
No experience	**0 (0.0%)**	**14 (14.3%)**	14 (12.0%)
Standalone games only	3 (15.8%)	5 (5.1%)	8 (6.8%)
Online games only	1 (5.3%)	17 (17.3%)	18 (15.4%)
Standalone & Online games	1 (5.3%)	20 (20.4%)	21 (17.9%)
Online & Multi-player online games	2 (10.5%)	6 (6.1%)	8 (6.8%)
Standalone, Online, & Multi-player online games	**12 (63.2%)**	**36 (36.7%)**	48 (41.0%)

We then examined gender difference in the attitudinal/belief variables. As shown in Table 3, male preservice teachers reported a stronger gamer identity than females (Mean = 3.54 for males vs. 1.95 for females). The gender difference on gamer identity is statistically significant, F (1, 115) = 57.534, p < .001, $\eta 2$= .333. There is no significant gender difference on gender stereotypes in computer gaming, perceived benefits of or perceived barriers to computer gaming in mathematics education, self-efficacy for using computer games in mathematics education, or intention to use computer games in mathematics education.

Table 3. Gender Differences on Key Attitudinal/Belief Variables

Variables	Male (N=19)		Female (N=98)		Combined (N=117)	
	M	SD	M	SD	M	SD
Gamer identity	**3.54**	**1.04**	**1.95**	**.79**	2.21	1.02
Gender stereotypes	2.26	.68	2.34	.73	2.32	.72
Perceived benefits	3.90	.61	3.90	.62	3.90	.62
Perceived barriers	2.74	.52	2.68	.74	2.69	.71
Self-efficacy	3.20	.89	3.00	.77	3.03	.79
Future intention	3.16	.77	3.06	.77	3.08	.765

Specialization of Teaching Attitude Differences

Besides gender, we also explored group differences related to the specialization of the teaching degree that the participants were pursuing at the time of our study. Originally, we intended to compare three groups: early childhood education, middle childhood education, and special education. However, there were too few middle school education majors in our study. Instead of having the middle childhood education as a separate category, we combined it with early childhood education and compared the combined category of early childhood or middle childhood (EC/MC) majors with special education majors. As shown in Table 4, the EC/MC group were more likely to report no computer gaming experience at all, while the special education group was more likely to report more advanced computer gaming experience that involves all three forms of games (standalone, online, and multi-player online games).

Table 4. Concentration of Study Differences in Computer Gaming Experience

Gaming Experience	Concentration of Study		
	EC/MC (n = 79)	Special Ed. (n = 38)	Combined (n = 117)
No experience	**13 (16.5%)**	**1 (2.6%)**	14 (12.0%)
Standalone games only	4 (5.1%)	4 (10.5%)	8 (6.8%)
Online games only	12 (15.2%)	6 (15.8%)	18 (15.4%)
Standalone & Online games	15 (19.0%)	6 (15.8%)	21 (17.9%)
Online & Multi-player online games	6 (7.6%)	2 (5.3%)	8 (6.8%)
Standalone, Online, & Multi-player online games	**29 (36.7%)**	**19 (50.0%)**	48 (41.0%)

Note. EC/MC = Early Childhood Education/Middle Childhood Education. Special Ed. = Special Education.

As shown in Table 5, compared to EC/MC preservice teachers, special education preservice teachers tended to have a stronger gamer identity and hold more positive attitudes towards the use of computer gaming in mathematics education (more perceived benefits, fewer perceived barriers, higher self-efficacy, and stronger intention for implementation). However, only differences in gamer identity reached statistical significance, F (1, 115) = 690.35, p = .045, η^2 = .034.

Table 5. Concentration of Study Differences on Key Attitudinal/Belief Variables

Variables	EC/MC (N=79)		Special Ed. (N=38)		Combined (N=117)	
	M	SD	M	SD	M	SD
Gamer identity	**2.08**	**.91**	**2.48**	**1.18**	2.21	1.02
Gender stereotypes	2.37	.69	2.23	.79	2.32	.72
Perceived benefits	3.87	.63	3.97	.60	3.04	.79
Perceived barriers	2.71	.75	2.66	.62	2.69	.71
Self-efficacy	3.01	.80	3.10	.78	3.04	.79
Future intention	3.03	.75	3.18	.80	3.08	.77

Note. EC/MC = Early Childhood Education/Middle Childhood Education. Special Ed. = Special Education.

Overall descriptive analysis combining the groups indicates that there were preservice teachers without computer gaming experience (12%), mostly females and those in early childhood/middle childhood education programs. Among those who have had some computer gaming experience, a small proportion of them either played standalone games only (6.8%) or played online and multi-player online games with no experience playing standalone games (6.8%). A slightly larger proportion of them never played multi-player online games, but either played online games only (15.4%) or played both standalone and online games (17.9%). The largest groups of game players were the ones that played standalone, online, and multi-player online games (41%).

Additional descriptive analysis of the combined groups' responses to individual items in the subscales sheds light on their attitudes and beliefs regarding specific aspects of computer gaming. Preservice teachers in our study generally agreed with the many benefits of using computer games in a mathematics classroom. They were particularly positive about the effectiveness of using computer games to promote motivation for learning mathematics (especially intrinsic motivation) and engagement in mathematics learning activities among students of different abilities, learning styles and learning preferences. The participants' concerns about using computer games in a mathematics classroom vary, though overall they reported a low level of concern about the potential barriers to the use of computer games. They seemed most concerned about lack of funds for covering technological costs related to game purchase, installation, and upgrading, and about technical issues (hardware, software, or network) that could occur during game playing. They were either a little concerned or somewhat concerned about the difficulty in finding appropriate games, lack of instructional materials to facilitate game integration, students' behavioral issues while playing games, lack of instructional time for teaching students how to use games, resistance from parents, lack of support from colleagues, and lack of time for familiarizing themselves with the games or incorporating games in the curriculum. They were least concerned about resistance from the students. Finally, the participants reported very few gender stereotypes regarding the use of computer games. They tended to disagree or hold a neutral stance with statements of gender stereotypes favoring boys over girls in computer gaming.

Multi-Level Linear Regression Analysis

We conducted multi-level linear regression analysis to examine the significance of each set of variables predicting the preservice teachers' intention to use computer games in future mathematics teaching. The predictors were entered in the following order: a) gender and previous computer gaming experience, b) gamer identity, c) gender stereotypes about computer gaming and self-efficacy for using computer games in mathematics education, and d) perceived benefits of and barriers to incorporating the use of computer games in mathematics education.

In the following, we report the results of the corresponding *F*-tests at each level of linear regression. First, neither gender nor specialization of teaching degree was a significant predictor of preservice teachers' intention to use computer games in future mathematics teaching, F_{change} (2,114) = .551, p = .578, η^2= .01. Second, previous experience of playing computer games and engaging in game-based learning and/or game-based teaching were significant predictors, F_{change} (3,111) = 4.151, p = .008, η^2= .10. Third, gamer identity was a significant predictor, F_{change} (1,110) = 15.416, $p < .001$, η^2= .109. Fourth, gender stereotypes about computer gaming and self-efficacy were not significant predictors, F_{change} (2,108) = 2.299, p = .105, η^2= .032. Finally, perceived benefits or barriers did not add more to the model for prediction, F_{change} (2,106) = 2.607, p = .079, η^2 = .035. Overall, the model predicted 28.6% of the variance in preservice teachers' intention to use computer games in mathematics teaching. Additional regression analysis indicates that computer gaming experience and gamer identity were both significant predictors of self-efficacy for using computer games in mathematics education. This may explain why self-efficacy failed to reach statistical significance after computer gaming experience and gamer identity were entered into the prediction model first.

Results of Qualitative Data Analysis

Our preservice teachers indicated that playing computer games is typically seen as an exciting activity among the students and student engagement would be enhanced when computer games are integrated in the teaching and learning processes. They stated that when students are given choices regarding specific games and game levels/features and the freedom to learn at their own pace, students' sense of autonomy increases and they become more intrinsically motivated. Another belief shared by the preservice teachers was that sustained engagement in game-based learning allows the students to interact more with mathematics content via the computer and interact more with peers either by sharing a computer device or by playing multi-player collaborative or competitive computer games online. For newly taught mathematics content, preservice teachers believed that computer games would provide an opportunity for students to engage in much-needed drill and practice with access to instant feedback automatically generated on the gaming platform. An additional benefit that the participants pointed out was that playing computer games could enhance students' technology competency and foster a more positive attitude towards technology.

Interestingly, the opposite of the above benefits can also be argued against the use of computer games in mathematics education. Our preservice teacher participants indicated that while computer games are exciting and engaging, they can also be distracting and addictive. Since learning activities based on computer games take place on a computer screen, some preservice teachers do not consider such activities as hands-on as other classroom activities (e.g., math manipulatives, measurement) that do not involve the use of computers. They were concerned that students may not be engaged in manipulating physical objects or solving mathematics problems in real life contexts. They were also worried that learning gains that takes place in the computer-based environment may not be transferred to off screen environments. Furthermore, in spite of the benefit of instant right/wrong feedback, some participants expressed concern that too much drill and practice via computer games may encourage rote learning and discourage higher order thinking. The benefit of peer interaction during gaming was not agreed upon by the preservice teachers, either. Some did not consider sharing a computer to play math games as real collaborative learning. Others believed that too much competition for computer access, game time or game performance can lead to more conflicts and fights among the students, which may disrupt the classroom, increase classroom management burden, and promote a less adaptive performance instead of mastery goal orientation among the students.

Many of the participants emphasized that teachers could use computer games to design student-centered, differentiated, and individualized instructional and learning activities. Some pointed out that computer games would allow students to learn at their own pace. Others indicated that computer games would allow the teacher to choose specific games and game activities to accommodate group and individual differences in interests, learning styles, and abilities among the students, especially among those with special needs. From these perspectives, computer games seem to be an effective tool for promoting educational equity for students from all backgrounds.

However, some preservice teachers expressed concerns about challenges and inequity for students from backgrounds that may put them at a disadvantage in game-based learning environments. One frequently mentioned concern was that students who start with lower technology competency or negative attitudes towards technology may be at a disadvantage. Another concern was that computer games may be designed without consideration of the needs of minority groups such as female students, younger students, English as a second language students, and students with special needs that present physical or cognitive challenges to playing or winning computer games. For example, playing games may be difficult without assistance for students with handicaps or visual or auditory processing impairment, and those with hand-eye coordination difficulties. A third concern regarding diversity and equity was that lack of home access to computers and high-speed Internet can put some students from low socioeconomic status families at a disadvantage and they may not benefit as much from game-based activities.

In terms of teaching load, the preservice teachers generally agreed that integrating computer games in teaching could increase their teaching load. Their concerns were that teachers could spend a great deal of time selecting, customizing, or developing appropriate computer games that align with specific instructional content or objectives, and time preparing lessons and course activities that incorporate computer games. It may also be challenging for teachers who are technologically less competent and those who have less positive attitudes towards technology. Even teachers who are competent and enthusiastic about computer game-based learning may face opposition from administrators and fellow teachers who do not share their competence or enthusiasm. Thus, the participants recommended that teachers receive sufficient training, practice, and support to overcome such barriers to computer game-based education.

The participants also noted the advantages and disadvantages of incorporating computer games for effective use of instructional time and classroom management. On one hand, they understood that computer games could allow teachers to use instructional time more effectively by providing one-on-one assistance to their students. As one preservice teacher wrote, games "give the teacher time to go around seeking out those that need assistance" without keeping the other students waiting. On the other hand, preservice teachers worried that setting up and familiarizing the students with computer games in the classroom might be time consuming and take away from valuable instructional time. In terms of classroom management, the participants saw how computer game time could be used as an effective incentive to reinforce good performance or good behavior among the students. However, they also anticipated more classroom management issues if the students fight over access to computer devices or over game time.

Discussion

The current study examined preservice teachers' experience with, attitude toward, and beliefs about computer gaming, particularly in the context of mathematics education. The results indicate that the majority of the participants had extensive computer gaming experience that involved one or more types of games (standalone, online, and multi-player online games). A small proportion of our preservice teachers had either no computer gaming experience at all (12%) or some computer gaming experience limited to one type of computer games (22.2%). Group comparisons indicate that the preservice teachers with no gaming experience were all female and almost all early childhood majors. Compared to findings of previous research that primarily involves in-service teachers, our findings paint a relatively brighter picture of pre-service teachers as more experienced gamers while indicating areas for improvement by revealing gender and program discrepancy. Since our participants represent the millennial generation, it is not surprising that the findings are highly consistent with the findings on millennial gamers in the most recent report on the computer and video game industry (ESA, 2019). According to this report, millennial gamers in the age range of 18-34 are more likely to be male than female (54% vs. 46%). ESA further reports other patterns of gender preferences: males are more likely to play games with their friends than females; males most often played games on their game console. This is also consistent with our finding that males tend to have much more extensive experience with a variety of computer games, especially multi-player online games.

With the rapid development of computer technology and the gaming industry, we can expect the younger generations to grow up with the experience of playing more sophisticated games such as massively multiplayer online role-playing games (MMORPGs). Thus, it is critical to provide training and practice for preservice teachers to gain more competence and confidence for playing a variety of computer games, especially serious games that are developed for or can be adapted for educational applications. Such training and practice would particularly benefit female preservice teachers and those who majored in early childhood/middle childhood education since our findings indicate these groups tended to have relatively less diverse computer gaming experience.

Our findings regarding preservice teachers' beliefs about the use of computer games in mathematics teaching and learning were generally positive. The participants noted many benefits of using computer games in mathematics education, especially in the area of student motivation and engagement, and in the area of accommodation and differentiation for diverse learners. Their concerns about the barriers to the use of computer games in mathematics education were mainly related to the financial and technical aspects of technology integration. Few of the participants appeared to hold gender stereotypical beliefs about computer gaming. Group comparison analyses based on gender and area of specialization indicate that male preservice teachers and special education majors tended to have more positive attitudes regarding computer games than female preservice teachers and early childhood/middle childhood education majors. A possible explanation is that males tend to have more diverse gaming experience and there are more males in our special education program.

The focus of the current study was using multi-level linear regression to predict preservice teachers' intention to integrate computer games in their future mathematics teaching. The results indicate that previous experience with computer gaming and gamer identity significantly predicted intention for integrating computer games in future teaching. While self-efficacy for and perceived benefits of instructional integration of computer games were significant predictors of preservice teachers' intention for game integration in future teaching, they did not explain significantly more variance beyond what computer gaming experience and gamer identity already explained. A likely explanation is that the effect of previous gaming experience and gamer identity was partially mediated through self-efficacy and perceived benefits.

The qualitative findings of our study provided a more comprehensive and in-depth view of the participants' thoughts about the use of computer games. Overall, preservice teachers' beliefs about the pros and cons of using computer games in mathematics education reflect conflicting views and significantly different perspectives. A summary of their written comments indicates that their beliefs are not to be polarized as opposites. Instead, they should be seen as representing two sides of the same coin. According to the participants, depending on the student characteristics and how one integrates computer games in teaching, computer games can enhance or hinder student learning. They do NOT believe that there is a computer game or game-based activity that fits all. Any specific game or game activity can only cater to the interest and needs of some students but not all. For example, game features that are exciting to boys may not be as exciting to girls, and vice versa. Students from different cultures and backgrounds may not find the same game or game activity equally relevant or appealing. Based on the qualitative findings, we recommend that diversity and individual differences be integrated in multiple aspects, dimensions and levels of computer games during game design and development.

Conclusion

Teachers and teacher educators should not only be aware of but also try to overcome stereotypical beliefs about computer games among themselves and among their students. Interests, preferences, and needs of students regarding computer gaming are not static but evolving entities. Group differences may change as a result of the interplay among a variety of biological, social, cultural, political, economic, educational, and experiential factors. Gender differences, for example, can be quite malleable via experience and socialization. In an experimental study, Master, Cheryan, Moscatelli, and Meltzoff (2017) randomly assigned six-year-old boys and girls to conditions with or without robot programming experience and found that significant gender gap in technology interest and self-efficacy was exhibited by the control group but not by the experimental group. Even in cases of well-documented group differences, it may be more helpful to pay attention to the variance within each group.

Nevertheless, findings from the present study provide important implications for teacher educators and policy makers in education. Teachers of all levels need adequate training and practice in incorporating effective use of computer games in their curriculum. An, Haynes, D'Alba, and Chumney's (2016) study showed that middle and high-school science teachers who had received training developed more positive attitudes toward the use of computer games in the classroom. Preservice teachers would also benefit from such training and practice. Specifically, teacher education curriculum should include training in pedagogically grounded and research-based integration of computer games. Previous research has explored the integration of inquiry-based and play-based pedagogical models in teaching with computer games to a limited extent. For example, Kennedy-Clark, Galstaun, and Anderson (2011) found a positive shift in preservice teachers' attitudes toward game-based learning as a result of a two-hour workshop on the integration of an inquiry-based educational game. In a case study, Denham (2017) explored three middle school teachers' experience of teaching with computer games using a pedagogical model that consists of four phases: play→ curricular activity → reflection → discussion. The findings indicated that teachers felt more effective in implementing the play and curricular phases than they did implementing the reflection or discussion phases. Teachers also felt that low achieving students benefited more from the use of digital games and recommended that successful implementation of the full pedagogical model should be adapted based on the composition of their class.

It is necessary to educate preservice teachers about the benefits of using computer games in the classrooms based on research and cognitive learning benefits so that they can develop accurate understanding and be more motivated to learn about educational uses of computer games. Preservice teachers may also benefit from the resources on highly recommended domain-specific computer games and online communities with shared knowledge and experience of applying computer games to the teaching of specific content. In addition, field services shall work with mentor teachers and supervisors to encourage and support preservice teachers' experimentation and exploration of integrating computer games in the teaching and learning of various subjects. Without a supportive environment for experimenting with innovative technologies, preservice teachers would neither gain the right experience nor sufficient confidence regarding computer game-based teaching and learning. Unless we equip them with the relevant knowledge, skills, and experience, they would be reluctant to incorporate computer games in future teaching and the many benefits of computer games for education indicated in previous research would not be realized in the K-12 classrooms.

There are a few limitations with our study. First, our sample consists of predominantly female pre-service teachers seeking licensure in early childhood education and special education programs. Findings of this study may not generalize to other populations with more males or middle and secondary education majors. Future studies should examine whether the findings could be replicated with male preservice teachers or preservice teachers in other programs than early childhood or special education. Second, our sample size is not large enough to allow additional analyses such as structural equation modeling to test the direct and indirect effects of different variables. Future studies with a larger sample size would provide better insight into the intricate relationships among the predictors of preservice teachers' intention to use computer games in mathematics teaching. Finally, the prediction model explained approximately a quarter of the variance in the criterion variable. More variance may be explained if we add predictors that we did not consider in the current study. Measurement issues could have played a role, too. Future researchers may fill in this gap with better theoretical conceptualization and improved validity of each measure.

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